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Micrographia Illuſtrata:

OR THE

MICROSCOPE

EXPLAINED.

Pl. 1.

The Variable MICROSCOPE,
and Lamp. *By George Adams Nº 60,*
Fleet-Street London.

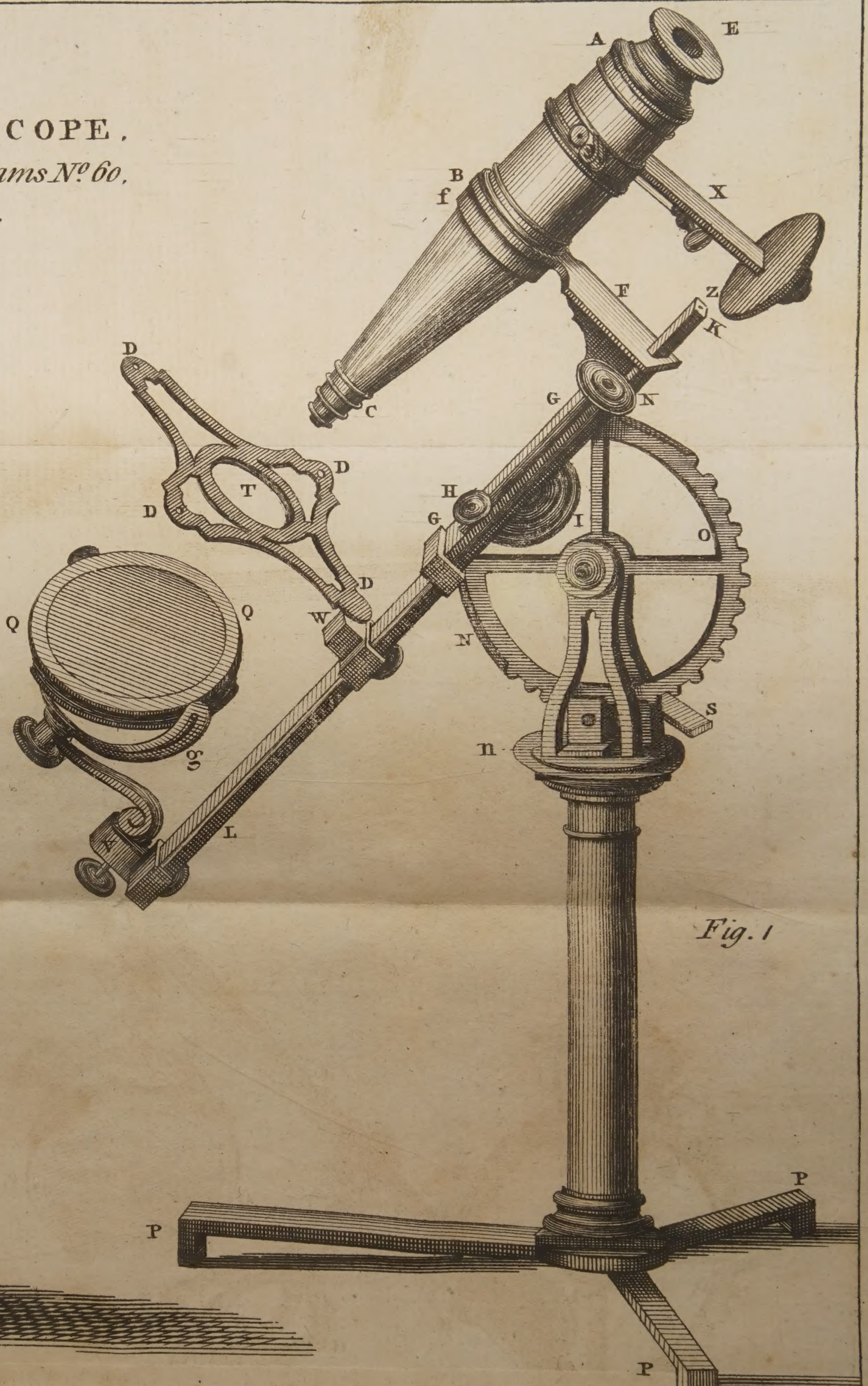

Fig. 1

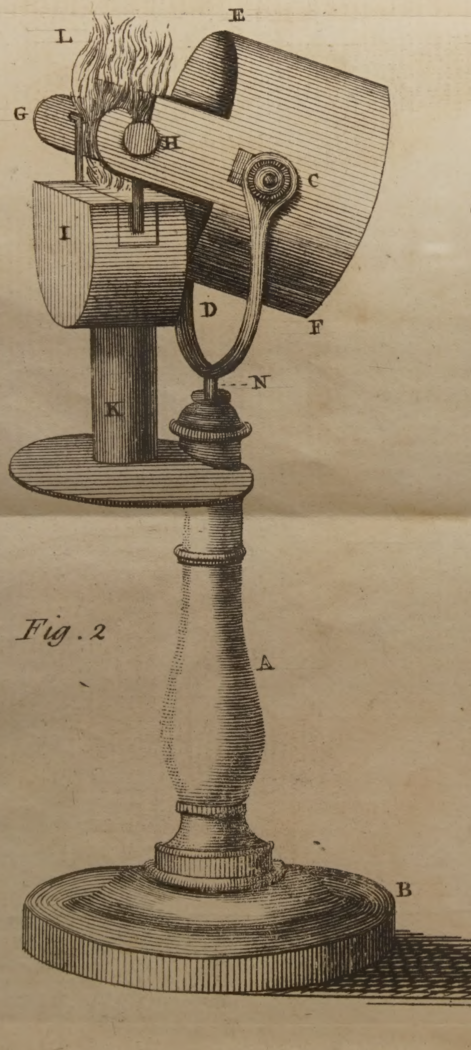

Fig. 2

Front. the title page

Goodnight sculp.

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Micrographia Illuſtrata:
OR THE
MICROSCOPE
EXPLAINED,
IN SEVERAL NEW INVENTIONS,
Particularly of a New VARIABLE MICROSCOPE for Examining all Sorts of Minute Objects;

AND ALSO OF A

New CAMERA OBSCURA MICROSCOPE,

Deſigned for Drawing all Minute Objects, either by the Light of the Sun, or by a Lamp in Winter Evenings, to great Perfection;

WITH

A Description of all the other Microſcopes now in Uſe.

LIKEWISE

A NATURAL HISTORY of Aerial, Terrestrial, and Aquatic Animals, &c.
Conſidered as Microſcopic Objects.

By GEORGE ADAMS,
Mathematical Inſtrument-Maker to His Majesty.

THE FOURTH EDITION.

Illuſtrated with Seventy-two Copper Plates, containing 560 Delineations of various Microſcopic Objects.

LONDON:
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M.DCC.LXXI.

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PREFACE.

THE ſtudy of nature, or, in other words, a ſerious contemplation of the works of God, is certainly one of the moſt pleaſing and uſeful, as well as moſt extenſive kinds of knowledge. It is indeed the great and proper object of our rational faculties; for ſurely we cannot employ our reaſon better, than in endeavouring to make ourſelves acquainted with the glorious works of that Being, to whoſe goodneſs we owe our own.

Natural Philoſophy is now ſo greatly improved in all its ſeveral branches, that few perſons, who have had the happineſs of a liberal education, are wholly unacquainted with the value of it. But prejudice is ſo prevalent, that we are apt to form an abſolute judgment of the works of nature from outward appearances only; and ſo imagine, that the moſt grand and magnificent parts of the creation are moſt perfect, and for that reaſon moſt worthy of our regard. The ſplendor of the ſun is viſible to every eye, and we need only look upwards in order to be convinced, that nothing leſs than an infinite power and wiſdom could firſt create the univerſe. What, but an Almighty hand, could raiſe ſuch a glorious canopy as that of the heavens, ſo richly adorned with ſtars? Or ſtretch out ſuch a ſpacious area, as this terraqueous globe on which we tread, and ſail; and which is furniſhed with every thing that is neceſſary for our ſupport or happineſs? And indeed theſe great truths are ſo very obvious to the loweſt capacities, that few perſons pretend to diſpute them; but then it muſt likewiſe be owned, that men are generally apt to confine their attention to the moſt ſhining parts of philoſophy, and ſo treat every thing elſe with coolneſs and indifference, and even with ſome degree of contempt. But ſurely a true philoſopher is one, who diligently purſues the ſtudy of nature, in all its ſeveral branches; who can behold with admiration her nobleſt productions, and yet view with pleaſure the ſmalleſt of her works; in ſhort, one who thinks every thing excellent, that owes its formation to her ſkilful hand. Nor is this a forced and imaginary deſcription, but a real character; and we need only take a tranſient view of ſome of thoſe creatures, with which all parts of the earth are ſo plentifully ſtored, in order to be convinced of the juſtneſs of it. For whether we regard their elegance, and beauty; or conſider their fitneſs to anſwer thoſe purpoſes, for which they were deſigned; in both theſe reſpects we ſhall find, that the ſmalleſt creatures are perfect in their kind, and carry about them as ſtrong marks of infinite wiſdom and power, as the greateſt. How many curious animals inhabit the air, and what numbers traverſe the deep waters! The whole earth is full of life; there not being a ſingle tree, plant, or flower, but what affords food and ſhelter to a ſpecies of inhabitants peculiar to itſelf. And then if we call in the aſſiſtance of art, what a new ſcene of wonder opens to our view? What an infinite variety of living creatures preſent themſelves to our ſight? Indeed their extream minuteneſs may at firſt ſeem a juſt argument for that low opinion, which too many are apt to entertain of them; however, if we examine them with cloſeneſs and attention, we ſhall ſoon diſcover their divine original. We ſhall then ſurvey with admiration the wonderful art and mechaniſm of their ſtructure, wherein ſuch a number of veſſels, fluids, and movements, are collected into a ſingle point, and that often inviſible to the naked eye. What a profuſion of the richeſt ornaments, and gayeſt colours, are frequently beſtowed upon one little inſect! and yet there are millions of others, that are as beautiful and wonderful in their kind. Some are covered with ſhining coats of mail; others adorned with plumes of feathers; and all compleatly furniſhed with thoſe weapons, that are moſt proper for defending themſelves, as well as attacking their enemies. In ſhort, the more we enquire into nature, the more excellent ſhe appears, and we ſhall conſtantly find, that the beauty of her works will gradually riſe in proportion to our knowledge of them. There is no ſuch thing as meanneſs in any of her productions; ſome indeed may be more grand, and happen to ſtrike our ſenſes more ſtrongly than others, but all are perfect in the higheſt degree.

If then a ſerious contemplation of the works of God, may juſtly be conſidered as an excellent kind of knowledge, and worthy of our purſuit; and if all thoſe works, though different in degrees of ſplendor, are ſtill perfect; it is hoped, that an humble attempt to improve, and encourage the ſtudy of any branch of Natural Philoſophy, will not be unacceptable to the public. And ſince the knowledge of the microſcope has always been looked upon as no inconſiderable branch of Natural Philoſophy, and as that part of it has particularly fallen within the compaſs of my ſtudies, I have made it the ſubject of the following treatiſe; a ſubject, which has ſo often employed the moſt learned men, that it can hardly ſtand in need of an apology for the choice of it.

In this edition is given a deſcription of ſeveral new and valuable diſcoveries.

I. The new variable microſcope, which is both ſingle and compound.

II. A beneficial improvement of the ſolar microſcope, in which we have ſucceeded beyond expectation. By this acquiſition, we have now an opportunity of examining all microſcopic objects, either in the ſun-ſhine, or at night in winter evenings.

III. A new application to the pyramidical camera obſcura, by which means perfect drawings may be taken of all thoſe beautiful microſcopic objects we are enabled to collect, by tracing their out-lines either with a pen or pencil, and that by any perſon who is not accuſtomed to drawing.

IV. We have given a deſcription of the camera obſcura, and have ſhewn how to apply it in taking perſpective views of any landſcape, in three different forms of the ſame inſtrument, by which means faces may be out-lined to great exactneſs, and pieces of ſtill-life drawn from nature.

V. We have likewiſe added a new compendious pocket microſcope, which is both ſingle and compound.

VI. We have alſo given a deſcription of the beſt kind of modern microſcopes now in uſe, that the reader may comprehend the utility of each, and thence be enabled to judge, which may ſuit his purpoſe beſt.

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Micrographia Illuſtrata:

OR THE

MICROSCOPE

EXPLAINED.

A deſcription of the new variable microſcope.

BY this microſcope we are enabled to examine the ſtructure, and diſcover the various and ſurpriſing contrivances, in the exact and uniform proportion of the minute parts of the creation; either in animals, inſects, foſſils, or vegetables, &c.

We owe the conſtruction of the variable microſcope to the ingenuity and generoſity of a noble perſon. The apparatus belonging to it is more convenient, more certain, and more extenſive than that of any other at preſent extant; conſequently the advantage and pleaſure attending the obſervations in viewing objects through it, muſt be as extenſive in proportion. I ſhall not detain the reader with dwelling upon its merits, but leaving the inſtrument to ſpeak for itſelf proceed to a deſcription of its ſeveral parts.

A B C, fig. 1 and 3, repreſent the body of the microſcope which contains two eye glaſſes at A, a third near B, and a fourth in the conical part between B and C, the end C ſhews one of the magnifiers ſcrewed thereto.

Hence the body of this microſcope, conſiſting of five glaſſes, greatly exceeds the uſual compound microſcopes which have only three, by increaſing the field of view and of light, as well as affording an occaſional opportunity of increaſing the magnifying power of each particular lens, or magnifier; this is performed by pulling up the part A E which ſeparates at A; there is likewiſe another ſeparation at B, by pulling up the outward tube A B.

Another advantage attending this inſtrument is, that any two of the magnifiers may be uſed at the ſame time, as follows, ſee fig. 3. ſcrew the button b to the part c of the button a, and both together into the body at c, the magnifier repreſented at c being firſt removed.

There are ſeven of theſe buttons repreſented at a and b, with magnifiers in them, alſo ſix ſilver ſpecula highly poliſhed, each having a magnifier adapted to the focus of its concavity, one of theſe is repreſented at e; when uſed they are to be ſcrewed into the body of the microſcope at c, every one of the ſeven magnifiers in the buttons a, b, may be uſed with any one of theſe ſpecula, by ſcrewing the lower part of the fruſtrum of a cone, which is ſeen at d, upon the prominent ſcrew on the ſilver ſpeculum at e, and then ſcrewing the part c of any button b into its upper end, and altogether into the body of the microſcope at c.

Note, theſe magnifiers are numbered, 1, 2, 3, &c. and the leaſt number is the greateſt magnifier.

The body of the microſcope A B C is ſupported by an arm F, into which it may be put or taken out occaſionally, and faſtened by the ſcrew at f; this arm is fixed to the bar G G, which may be raiſed or depreſſed by turning the large ivory head I; the ſcrew at H being firſt diſcharged, G G ſlides cloſe to the upper part of the long bar K L, which laſt is fixed at N and N, to the toothed wheel N O N, this wheel being ſtrongly ſupported by four ſcroles whoſe extremities are connected to an horizontal plate n, which gives an horizontal motion to the wheel N O N, the bar K L, and every other part of the microſcope which is connected thereto, the whole being ſupported upon the pillar M, by the three feet P P P.

In fig. 3. the variable microſcope is delineated from its perpendicular poſition, being that which gave the beſt repreſentation of its ſeveral parts. In fig. 1. it is drawn inclined, from a view of which there will be no difficulty to conceive that on turning the key S, the pinion which works in the teeth of the wheel N O N will give the bar K L, with the microſcope and its appendages, any oblique inclination that may be required.

The object carrying piece or ſtage D D D, has a large round hole T, in the middle over which we place the objects for obſervation, ſometimes in an ivory ſlider, No. 1. fig. 3. or upon a ſlip of glaſs, No. 2. or they may be put upon one of the round glaſſes No. 2. fig. 3. which are of various colours and fitted to the hole at T.

The concave mirror Q Q turns vertically on the extremities of the ſemicircle g, and horizontally in the cylinder h, by which means it may be turned into any direction, ſo as to reflect the light from a bright cloud through the center of the ſtage at T, projecting the image of the object thro' the body of the microſcope to the eye at E.

The mirror Q Q, may be extremely well illuminated at night by means of a new apparatus contrived for that purpoſe; it is repreſented at fig. 2. and conſiſts of a pillar A B, that ſupports a ſemicircle C D; on the extremities of this, a ſhort tube E F, turns upon axes, one of them is ſeen at C, a lamp I K is ſuſpended from the two ears G and H in ſuch a manner that at every inclination of the tube E F, the flame L may direct its light through the center of the tube, and alſo of a plano-convex lump contained therein, and thence through an oiled paper, or a grey glaſs, to the illuminating glaſs Q Q. The light thus tranſmitted to the mirror is amazingly fine, it being nearly equal to that reflected from a bright white cloud on a fine ſummer's day.

The object carrying piece D D hath a conical pin fitted to a hole in the ſlider W, in which it may be turned ſideways, ſo as to examine the ſeveral parts of any object that may be too large for the field of view.

The ſcrole h R, has alſo a conical pin fitted to a hole in the ſlider V.

By means of the ſlider W, the object carrying piece D D may be readily ſet nearly to its proper diſtance from the magnifier in the button at C, and then by turning the large ivory head I, the body of the microſcope may be brought to its diſtinct focus. But if this ſhould not be thought quite ſufficient, tighten the ſcrew at H, and thereby turning the ſcrew at X, the focus may be adjuſted to the eye of any obſerver with great preciſion, and by moving the ſlider V a little higher or lower, a proper ſpot of light of any convenient breadth may be readily obtained.

No. 3. is a cylindrical tube, in which an inner tube is forced upwards by a ſpring; its uſe is to receive an ivory or glaſs ſlider, No. 1 and 2, the object being firſt placed in the center of the hole at m, or the object may be laid upon a glaſs ſlider, No. 2. either of which are to be put between the plates h and i, and the cylindrical piece No. 3. put into the hole at T in the ſtage X to which it is fitted. The hollow at k is to receive the glaſs tube, No. 10. for confining a ſmall water animal to ſhew the circulation of the blood. No. 11. is a wier ſcrew to aſſiſt in cleaning the tubes, or to diſcharge their contents.

If the animalcula in fluids, or any minute inſect, are under conſideration, it will ſometimes be neceſſary to exclude ſome part of the light which is reflected from the mirror Q, by putting the cone No. 4. upon the bottom l of No. 3. it being firſt put into the ſtage at T.

The nippers No. 5. are for confining any object, and are to be placed in one of the ſmall holes near the extremities of the ſtage, or in the ſocket r, at the end of the chain of balls No. 6. as the pointed nippers t, which hold an opake object t v, the ſtage D D being removed, and one of the ſilver ſpecula ſcrewed to the body of the microſcope at C, the ſlider W brought nearer to the ſlider V, the ſtem X of the pillar belonging to the chain of balls, being put into the hole at W, the balls may be readily managed to give a proper direction to the object t v, the obſerver's back being turned towards the window, ſo that the reflection from the mirror Q, of the ſky behind, or on one ſide, may fall upon the ſilver ſpeculum, and thence be returned upon that part of the object t v, which is to be examined and is next the eye.

No. 7. is a box, containing ſpare talcs to ſupply the ivory ſliders.

No. 8. is a double convex lens, to be uſed as a magnifier in the hand.

Laſtly, remove the body A B C, and put the ſtage D D in its ſtead, at B in the arm F; alſo put the pin f of No. 9. into the hole at z in the top of the bar K L, fig 3. place an object upon the ſtage, and ſcrew any one of the magnifiers before deſcribed into the end e of the ſliding bar e g, and then this inſtrument becomes a ſingle microſcope to which all the above apparatus is applicable; but for the uſe of the ſingle microſcope only, there are added three more magnifyers whoſe foci is very ſhort.

There

There are alſo added to this apparatus already deſcribed, two glaſs planes broader than that of No. 2. and two others with hallows ground in them; they are to be laid upon the ſtage D D, to receive any accidental object that may occaſionally offer. Small live inſects may be confined between two of them, one having a hollow, and the other being a plane ſurface. Thoſe with hollows in them are proper to obſerve the animalcula in fluids, being laid upon the ſtage.

The circulation of the blood may alſo be very well obſerved in the tail of any ſmall fiſh, as well as between the toes of a frog, by tying it to one of the long glaſs plates, marked No. 2. in fig. 3.

There are likewiſe a few flat round glaſſes, No. 12. of different colours, fitted to the hole T, in the ſtage D D, and a watch glaſs fitted to the ſame place, which will hold more water than the hollows in the long glaſſes juſt above mentioned, and a ſett of glaſs tubes, No. 10.

To theſe if deſired may be added a micrometer, and a frog frame, which will be deſcribed in their proper places.

There are two ſockets fixed to the ſlider W, one of which is ſeen at p, fig, 3. Their uſe is to hold the frog frame if required.

The uſe of the improved ſolar microſcope.

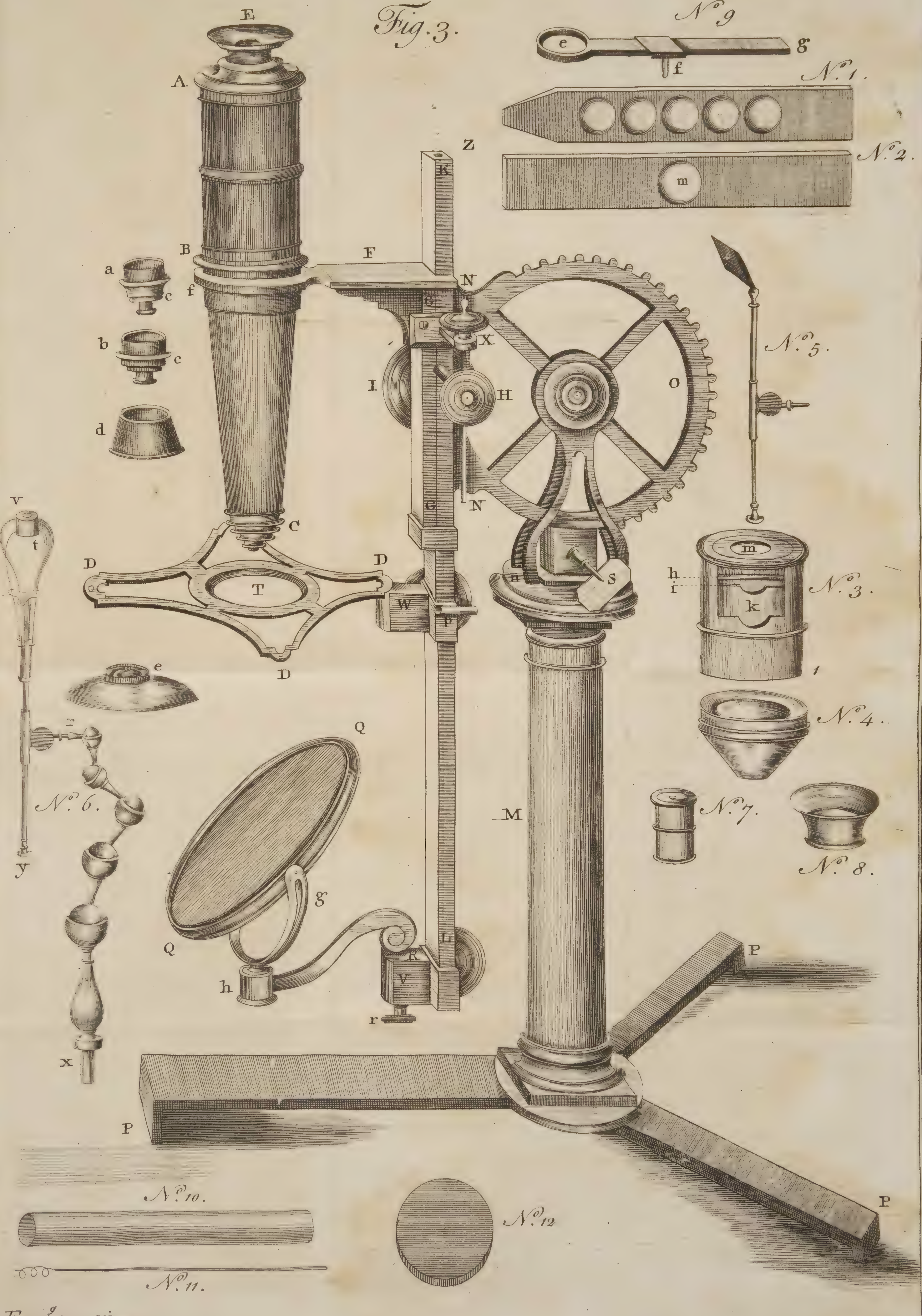
THIS microſcope, from the very great extent of its magnifying power, and the convenience of viewing any object by many perſons at one and the ſame time, gives more ſatisfaction and greater pleaſure than any other microſcope to the generality of obſervers; as will appear by the following directions, in ſhewing how it is to be applied.

Plate 2.

THE VARIABLE MICROSCOPE

By George Adams, Nº. 60, Fleet-Street, LONDON.

Fig. 3.



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Make a round hole in the window ſhutter, about 4 and 1-8th inches diameter; to which apply the ſquare plate A A, fig. 4. with the circular part D uppermoſt, then mark the places of the two holes a a with a ſmall black lead pencil, and bore them through the ſhutter of a ſize ſufficient to let the mill'd headed ſcrews B B paſs freely through them, which entering the holes a a, will hold the plate faſt to the inſide of the window ſhutter; the looking-glaſs C, being firſt put through the hole, will remain on the outſide of the window, the ſaſh or caſement being firſt thrown open.

Screw the part b b of the ſliding tubes I K into the hole at H. Then prepare the microſcope fig. 5. for obſervation. Take out the tube I, and ſcrew the tube M into the end N of the microſcope N P, and put the ſhort ſlider R that contains a convex lens, to increaſe and enlarge the field of light, into the dove-tail plate g k h.

Place the object which is ſuppoſed to be either in an ivory or on a glaſs ſlider, as E or F, between the thin plates c d and g h, then ſcrew on one of the magnifiers at the hole i. There are ſix belonging to this tooth and pinion microſcope, and one of them is repreſented at Y. Or if the magnifiers are placed in a wheel as P Q * turn it ſo as to bring one of them under the center of the hole at i. Then darken the room as much as poſſible, that no light may enter, but what paſſes through the tubes I K. From this circumſtance, and the brightneſs of the ſun-ſhine, you are only to expect a perfectly clear and diſtinct image.

Now adjuſt the looking-glaſs C to the poſition of the ſun, by turning the heads at e and f, the firſt inclines the mirror to the right or left, and the other raiſes or depreſſes it, ſo as to reflect an horizontal ray of the ſun's light through the tubes I K, upon a ſcreen of white paper placed about five or ſix feet from the window, which will form thereon a round ſpot of light.

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* Note, we prefer the uſe of the magnifiers ſet in round buttons as repreſented at Y, inſtead of being ſet in a circular plate P P.

Laſtly, ſlip the tube I into that marked K, together with the microſcope and object as before prepared; and if the ſun then ſhines bright, you will have a diſtinct image of the object upon the ſkreen, by turning the button at O to remove the magnifier to its proper focal diſtance.

There are ſix magnifiers in the wheel P Q, which turn round for the greater eaſe in changing from one magnifying power to another. When the room is darkened, all the magnifiers * are numbered, 1, 2, 3, &c. the leaſt number being the greateſt magnifier.

In the box with this microſcope, there are alſo three ſhort braſs ſliders, like that marked R, for increaſing the field of light: on the firſt is engraved 1 and 2, to ſhew that this is only to be uſed with the firſt and ſecond magnifiers. The ſecond braſs ſlider like R, being marked with the numbers 3 and 4, are to be uſed with the third and fourth magnifiers, and no other; and the third having the numbers 5 and 6, is only to be uſed with the fifth and ſixth magnifiers. This is a principal improvement in the ſolar microſcope, ariſing from the great increaſe of light we obtain thereby. The ſame advantage is gained when N P, which we call the tooth and pinion microſcope, is uſed alone as a ſingle microſcope.

We have ſhewn above how to form a round ſpot of light upon the ſkreen, but this cannot always be attained, becauſe the ſun's apparent altitude to the inhabitants of

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* We prefer the magnifiers ſet in round cells as at Y, to thoſe ſet in a wheel as P Q.

of northern latitudes in the winter, is ſo near the horizon, and more eſpecially when the ſun is directly perpendicular to the front of the room, it cannot then form a ſpot of light perfectly round; but if the ſun be on either ſide of that perpendicular, a round ſpot may be obtained.

The moſt uſeful magnifiers in the ſolar microſcope, are the fourth, fifth, and ſixth.

Care muſt be taken to pull out, or thruſt back, the tube I more or leſs, as the object is capable of ſuſtaining the ſun's heat, ſo that the ſpot of light may be broad enough to cover the object. Dead bodies may be placed within about an inch of the focus of the double convex lens, which diſtance muſt be ſhortened for living creatures, or they will ſoon be killed.

If the light falls not exactly right, you may eaſily direct it thro' the axis of the microſcopic lens; and there keep it during the time of your examination, by the help of the ſcrews f and e, by following the ſun's motion.

Having taken notice of a ſcreen to throw the images of objects upon, ſuch a ſcreen is uſually made of a ſheet of the largeſt elephant paper, ſtrain'd on a frame, which ſlides up and down on a round mahogany pillar, in the manner of ſome fire ſcreens. A larger ſort are compoſed of ſeveral ſheets of the ſame paper paſted together on cloth, and let down with a roller from the ceiling in the manner of a large map.

Fig. S. which is ſeen below the figures 4 and 5. repreſents that additional part of a ſolar microſcope, which is deſigned for the examination of larger tranſparent objects, than can be contained in the apparatus already deſcribed, and is called a magelleſcope.

When this is to be uſed, unſcrew the cap T V, from the inward ſliding tube I, and ſcrew the apparatus S in the place of it, the ſliders for this purpoſe are made of mahogany as W, with three large round holes, each furniſhed with a pair of thin glaſſes; theſe are to be put between the plates r ſ, and t v, then by turning the button w, the convex lens or magnifier z, may be removed to a proper focus, ſo as to exhibit a diſtinct image of the object upon the ſcreen. There are three ſuch mahogany ſliders, like W. and three others with larger holes repreſented at X.

A deſcription of the tooth and pinion microſcope, conſidered as a ſingle microſcope.

THIS inſtrument N P, fig. 5. with its apparatus of ſix magnifiers fixed in buttons like Y, which are to be ſcrewed into the end i P, inſtead of the wheel P Q, makes a complete and uſeful ſingle microſcope, when put into a pocket caſe with ivory ſliders E, glaſs ſlips F, ſmall braſs ſliders R, glaſs tubes, &c. the uſe of each of theſe parts have been already ſhewn. To which may be added to the ſide of the microſcope, an arm or handle, when deſigned to be uſed with the aquatic or Mr. Ellis's microſcope, which will be deſcribed hereafter.

The uſe of the new improved ſolar microſcope, applied to a new improvement on the pyramidical camera obſcura, when illuminated by the ſolar rays.

SEE figure 6. in which A B, A C, repreſent two ſides of the camera obſcura when put together, its upper ſliding tube repreſented at P Q, fig. 8. being taken out and laid aſide, the circular box A D F, put on in its ſtead and held faſt by two bolts, this being done, ſlide the arch G H, fig. 6. into its receptacle at K, and ſet the degree anſwering to the latitude of the place you

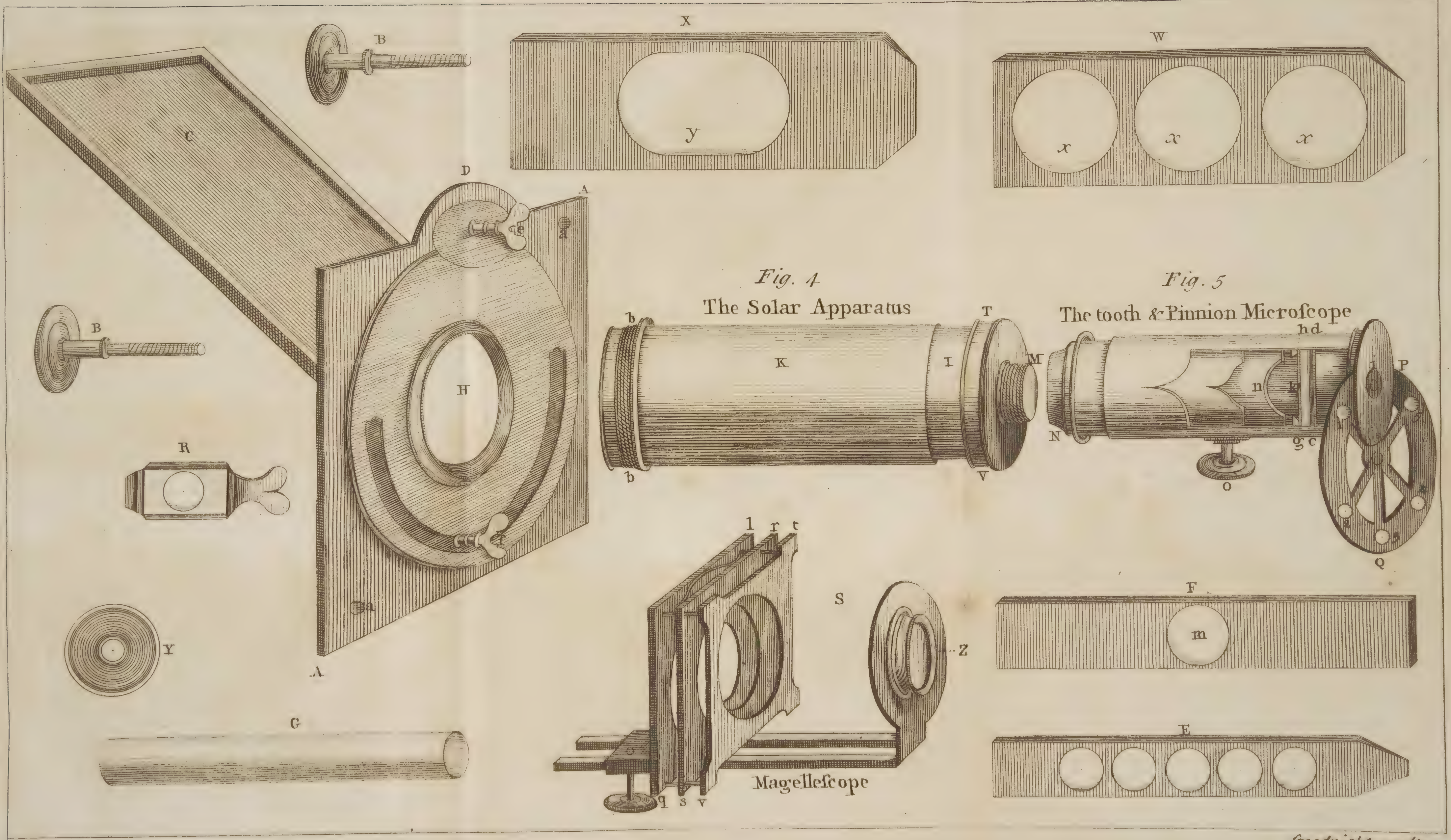

Fig. 4
The Solar Apparatus

Fig. 5
The tooth & Pinnion Microſcope

Magelleſcope

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Goodnight sculp

you are in, to the point of the flower-de-luce at K, then tighten the ſcrew at f, to fix the arch; by this means the axis I L upon which the mirror M N turns, will be properly elevated above the horizon of the place.

Screw the part b b of the tube K, fig. 4. into the inſide of the top of the box A D F, fig. 6. there being a braſs plate at F prepared for its reception: then ſcrew the little tube M to the end N of the Microſcope, N P, fig. 5. and put an object between the plates e d, g h, as before directed in the deſcription of the ſolar apparatus.

Now ſet the camera upon a table placed nearly level in the ſun ſhine, turn it about that the direction of the ſide E B may be nearly in the meridian; if you have no meridian line, a ſquare magnetic compaſs box T V applied in the direction of the ſide C O, but to the back of the camera which is oppoſite and parallel thereto, and perpendicular to the ſide E B. Now turn the whole inſtrument together with the compaſs box, until the needle reſts over the degree of its variation at the place you are at *, then the axis I L will be nearly parallel to the axis of the equator, and give an equatorial motion to the mirror M N.

Put a ſheet of paper into the camera, and fix it there by wafers, wax, or needle points fixed in very ſmall braſs buttons. Elevate or depreſs the mirror M N, by taking hold of it at N, and if neceſſary, turn it a little ſideways, until you obtain a round ſpot of light upon the paper, by looking at it through the apperture, a b c.

Then ſlip the tube I, together with the microſcope N P. fig. 5. with an object applied to it, into the tube K of the ſolar apparatus, fig. 4. Turn the milled head ſcrew O, of fig. 5. to bring the magnifier to its due focal diſtance, from the paper on the inſide of the bottom

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* Note, the variation of the magnetic needle in London, is about 21 degrees from the north towards the weſt.

tom of the camera, and you will obtain a lively image thereon.

Now ſhut the doors R S, ſit down with a pencil in your hand, button the band m n upon your wriſt, place your forehead cloſe upon the cuſhion a b c, with your noſe on the outſide at a, that you may be able to breathe the free air; and by this means you may make an exact drawing of every microſcopic object that you chuſe to convey to poſterity, or to oblige your friends with your own remarks thereon.

As the ſun appears to move continually towards the weſt, the brightneſs of the light which ſurrounds the image of the object will diminiſh on one ſide, then turn the milled button I, fig. 6. extreamly ſlow the ſame way with the ſun's apparent motion, and you will have the ſame brightneſs as before. This muſt be occaſionally repeated, by which an intelligent reader will inſtantly diſcover, that we have after the above preparation but one ſingle motion to attend to, in order to preſerve a proper illumination upon the image of the microſcopic object intended to be drawn, until its out-lines are complete. From this valuable improvement, all ſcientific perſons, whoſe knowledge prompts them to relate ſuch diſcoveries as their reſearches engage them in, will be enabled to explain themſelves much better by a picture of what they may be deſcribing, which they may make themſelves, without the aſſiſtance of a draftſman, and may by proper letters of reference convey their own ideas in ſuch an extenſive light, that is beyond the power of the moſt elegant writer, who, without a drawing, has, or may attempt to make himſelf underſtood.

As we have in this conſtruction but one motion to attend to, in preſerving a proper illumination upon the image of the object, much time and trouble is ſaved: whereas in all the former conſtructions there are two motions to be attended to, and that with very much difficulty,

ficulty, even ſo as to make it tireſome to the operator, which is here removed. *

The circular box A D F, is repreſented at fig. 6. in the moſt convenient poſition for uſe, the axis I L being over the drafts-man's head, in which caſe his back muſt be turned toward the ſouth, which will oblige him to ſit between the window and the inſtrument, if the upper ſaſh can be pulled down, but if the under ſaſh is only moveable, the box A D F muſt be changed, ſo that the axis I L may be over the back of the camera, then the inſtrument may be puſhed cloſe to the window, and conſequently the drafts-man's back will then be turned to the north; but if a large garden or open plain be near the houſe, it will, when the weather permits, be better to ſit out of the houſe, where no buildings or other obſtacles can intercept the ſun's rays, whence we ſhall have no interruption from the jambes between the windows, &c.

The uſe of the new improved microſcope, applied to the new pyramidical camera obſcura, when illuminated at NIGHT by a peculiar lamp contrived for that purpoſe.

THIS uſeful invention is the reſult of a great many experiments that have been made for ſome years paſt, to illuminate microſcopic objects in winter evenings, which has ſucceeded far beyond our expectation. And although we have applied it to the pyramidical camera obſcura, as being the beſt form for theſe kind of experiments, yet they may be performed in a box of any

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* Note, in this application of the ſolar microſcope, we intirely omit the ſquare plate A, the mirror C, and ſcrews B B.

any other ſhape, let its form be what it may; but not with ſo much ſatisfaction.

Take off the circular head A D F, fig. 6. and then the upper part A D w r of the pyramid, fig. 6. ſet the laſt aſide. Take out the grey glaſs which is placed in the inſide of the lower part of the camera when it is not in uſe, and put it into the hole p q, which is repreſented at fig. 7. and then put on the cover Z Y; ſcrew it faſt by the two ſcrews, one of which is ſeen at e, and place the circular box A D F upon the cover Z Y, and bolt it faſt; then lay it upon a table as it is repreſented in fig. 7. the apparatus fig. 4. and microſcope fig. 5. with the object intended to be examined being firſt prepared and placed within the box ADF, take the tube E F, with its ſemi-circle from the pillar A, fig. 2. (it ſeparates at N) and ſcrew it to the end F, of the circular box A D F, fig. 7. the rim with the oiled paper being firſt removed. Now light the lamp and ſuſpend it on the ears G H. Sit down at the table and look at the grey glaſs p q, and you will there ſee a beautiful image of the object you have placed in the microſcope. After having adjuſted the magnifier to its proper focal diſtance, by turning the ſcrew O, in fig. 5. and ſhut too the doors R S, of fig. 6. in this ſituation you may draw the out-lines of the object in the moſt correct manner, although the perſon is not accuſtomed to drawing. It may be firſt drawn upon the grey glaſs p q, and then covering that with paper, and holding it againſt the light, it may be finely copied upon the paper: or if you do not chuſe to draw it twice, place a piece of thin paper, vellum, &c. upon the glaſs p q, and it may be drawn at once.

The repreſentation of microſcopic objects in this eaſy manner without the light of the ſun, is extremely entertaining, as they appear in the higheſt degree a very fine picture. By this means we have obtained a very valuable

The Camera Obſcura
and
Solar Microſcope.

By George Adams,
N.º 60 Fleet Street London.

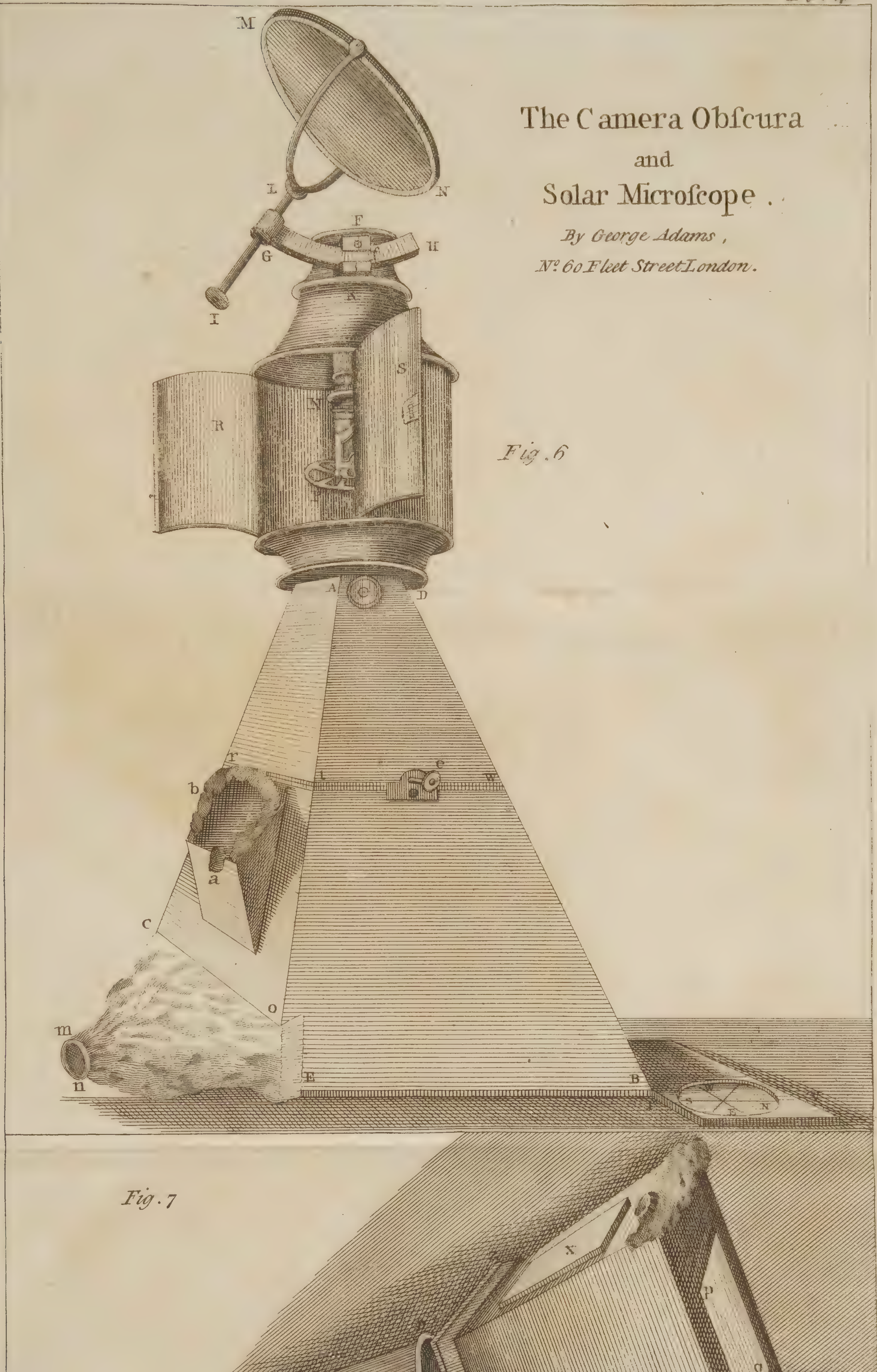
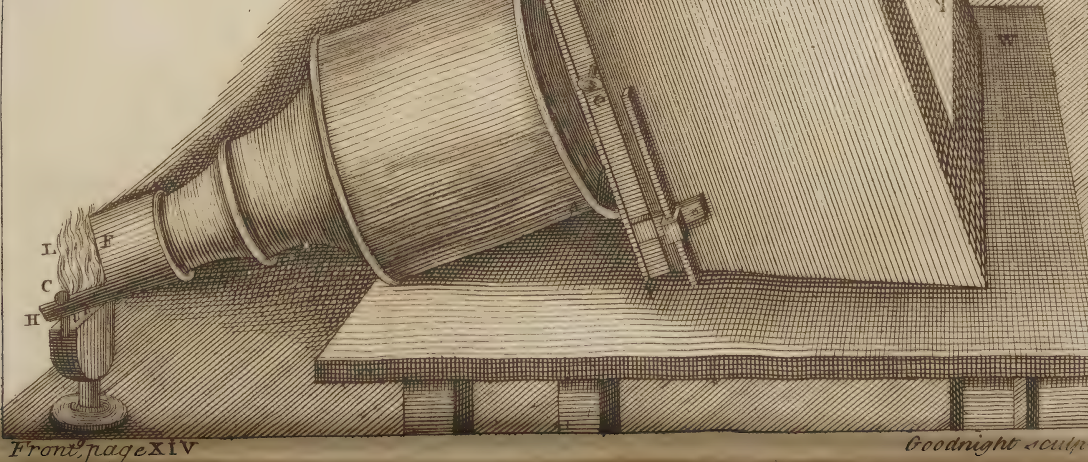


Fig. 6

Fig. 7



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Goodnight sculp.

ble acquiſition of having it in our power to keep drawings of thoſe beautiful appearances, which require no more trouble, than that of tracing the lines with a pen or pencil.

The uſe of the pyramidical camera obſcura, in deſigning and taking perſpective views.

A CAMERA obſcura, is any dark place, wherein objects expoſed to broad day light are repreſented upon paper, or any other proper white body, in their true proportions, with all the livelineſs of colours, and diverſity of motions, amazingly pleaſant to behold. The advantages ariſing from the uſe of this inſtrument, to draft's-men in general, are ſo great and ſo well known, as to need no enumeration. Therefore we ſhall only add, that it is of very great uſe in giving the proportionable ſize of every ſeparate object, or ſeparate groups of objects in the ſame picture; by which means they may be copied after nature in the moſt perfect manner, and that conſtant difficulty removed, which requires ſo much time and ſtudy to give the ſeveral objects their true bigneſs and proper ſituation in the picture from the ſame point of ſight.

There are two double convex lenſes in ſquare mahogany frames; one of which is to be uſed for diſtant, the other for near objects. They are to be put into the ſquare ſliding tube P Q, fig. 8. at d under the mirror r, their foci is marked upon each frame.

The pyramidical form of this inſtrument is allowed by a number of gentlemen who have experienced its utility, to be ſuperior to thoſe of any other conſtruction hitherto made, having every deſired advantage to exclude the light, and when you have done with it at any time, it is readily put up into a portable ſize.

Fig. 8. repreſents the pyramidical camera obſcura mounted for taking perſpective views, from any proſpect the draftsman has a deſire to imitate. After having choſe the ſpot or point of ſight from whence he would make his perſpective picture, let him cauſe a table to be placed there, and ſet the camera upon it. Let him ſit down before it, turn his back and the camera together, while he is looking through the apperture a b c, until he finds the moſt agreeable picture he can obtain (from that point of ſight) upon a ſheet of paper already placed on the inſide of the bottom of the inſtrument for that purpoſe. This being done, place your forehead cloſe to the cuſhion a b c, with your noſe on the outſide at a, that you may be able to breathe the free air, having firſt buttoned the band m n, upon your wriſt; then proceed with a pencil in your hand to trace the out-lines of every object in your landſcape, which will, when completely ſhaded, be a true repreſentation of that perſpective view. Your out-lines being finiſhed, take out the drawing; put another clean paper into the inſtrument, it ſtanding in the ſame place; ſit on one ſide of it that you may look into the camera occaſionally, and then you may ſhade your drawing agreeable to nature.

From the preceeding experiments and various trials made before the inſtrument was compleated, to exhibit microſcopic objects by the help of a lamp without the ſun, the two following curious applications of the camera obſcura offered themſelves, which we could by no means reject.

Fig. 9. repreſents the pyramidical camera obſcura placed horizontally upon a table; the mirror r in fig. 8. being taken out of the ſquare ſliding tube P Q, and the flat cover of the ſaid tube taken off, we put one of the convex lenſes into the groves made for that purpoſe, near the end of the ſquare tube at P. fig. 9.

Direct your inſtrument to any external objects and if your room is a little darkened, you will have an extremely vivid and beautiful picture upon the grey glaſs at r q fig. 9. But inverted, the outlines may be nicely traced with a black-lead pencil upon the glaſs, which being taken out and covered with a paper and held againſt the light, may be nicely copied, and afterwards ſhaded by the picture upon the glaſs, when put into its place, the black lead lines being firſt wiped off, with the corner of a napkin a little wet.

Note, this ſecond form of the camera obſcura hath the following advantages; firſt, as the picture is formed immediately, by the rays paſſing thro' the convex lens without any reflection, the objects are extremely vivid; and although the outlines muſt be traced in its inverted ſtate, yet when the glaſs is taken out and turned the other edge downward, every part of the picture will have its proper attitude.

Secondly, a very great advantage ariſes from this application of the inſtrument, in diminiſhing large drawings or paintings to a ſmaller ſize, viz. Set the original painting upon a chair againſt the wall, but topſide turvy, and you will have a lively repreſentation of it upon the grey glaſs in an erect poſition; and if the room be long enough, a whole length picture may be taken in, and the repreſentation may be either larger or ſmaller, as you either remove the inſtrument, or picture, farther from or nearer to each other; the change of the convex lens will do the ſame thing. When this operation is performed, the picture to be copied ſhould be placed near a window, and you ſhould ſit with the inſtrument, next a remote window, and ſhut the ſhutter of that or thoſe windows which are behind you, to exclude the light as much as poſſible, from falling upon the grey glaſs q r.

Thirdly, portraits may be correctly out-lined in this poſition of the inſtrument; and the greateſt poſſible likeneſs obtained. Side-faces in imitation of ſhadows, are likewiſe taken this way to great advantage.

Let the perſon, whoſe portrait or ſide-face is deſired, ſit on a chair, at the diſtance the picture was placed at, and keep himſelf as ſtill as poſſible.

The human attitude, in any poſition, may be admirably well delineated after the ſame manner.

Fourthly, pieces of ſtill life, ſuch as flowers, fruits, dead game, &c. may be elegantly copied this way, by ſetting them upon a ſtool, that is lower than the table, and pointing the inſtrument to your object.

All ſorts of furniture, workmanſhip of every kind, ſuch as mathematical inſtruments, models, buſts, china, or other images, &c. may be alſo delineated in the ſame manner.

The third application of the camera obſcura, is to repreſent objects in their natural ſituation without reflection. The preparation for this is as follows: take out the ſquare ſliding tube P Q, and place that convex lens, which is marked with No. 4. into that end of it which is alſo marked No. 4. and goes into the camera; then replace it again, as it appears in fig. 9. and put the tube W Z into the hole at P, until the ſhoulder m n, reſts cloſe to the ſurface at P, and the inſtrument will be ready for uſe.

In this ſtructure of the camera, it may be applied to all the experiments, related in the preceding application; but the field of view will not be quite ſo large; yet in this we have many advantages, from the objects appearing in their natural ſituation.

See fig. 8. in which A D E B repreſents one ſide of the pyramidical camera obſcura; A C O, the front; P Q, a ſquare tube, which may be moved higher or lower, by turning the knob at f, in order to adjuſt the focus of the convex lens placed at d, to make a diſtinct picture at the bottom of the inſtrument; a b c is the opening,

Pl. 5

Camera Obſcura *By George Adams No. 60 Fleet Street London*

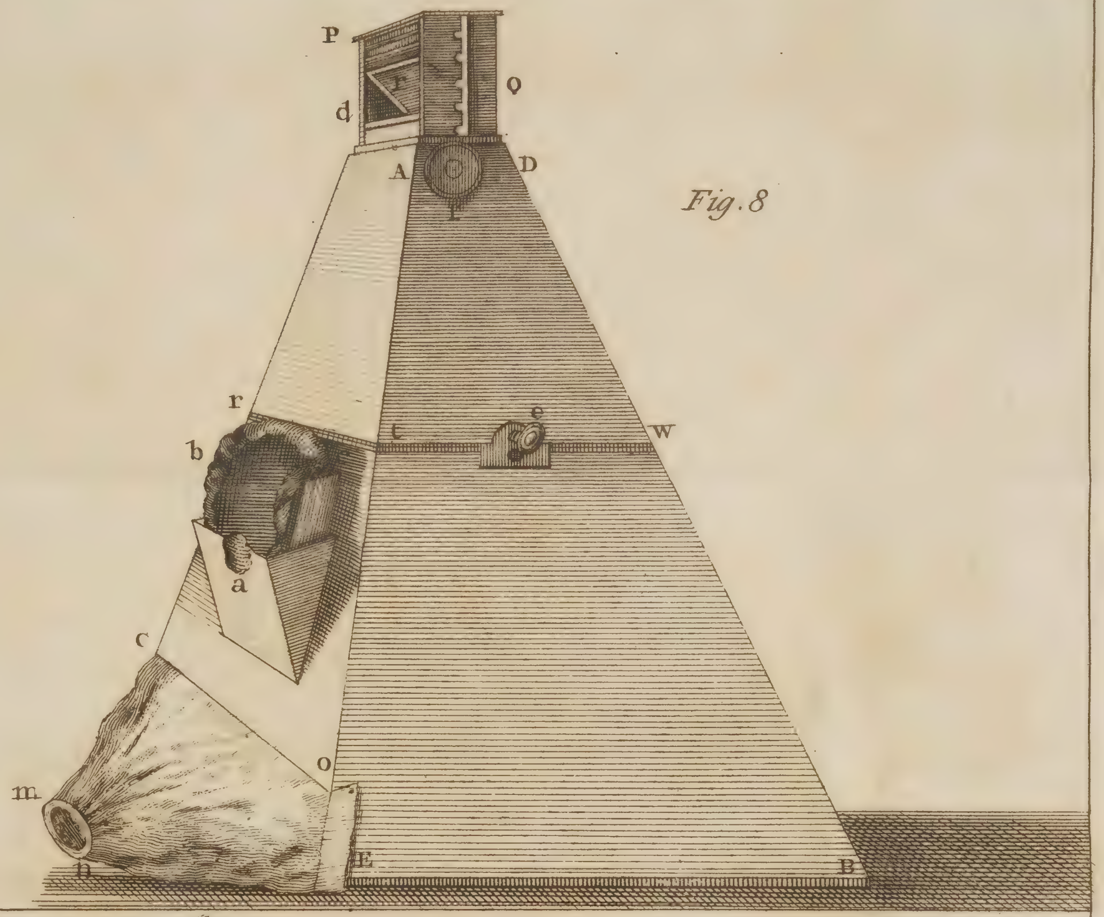

Fig. 8

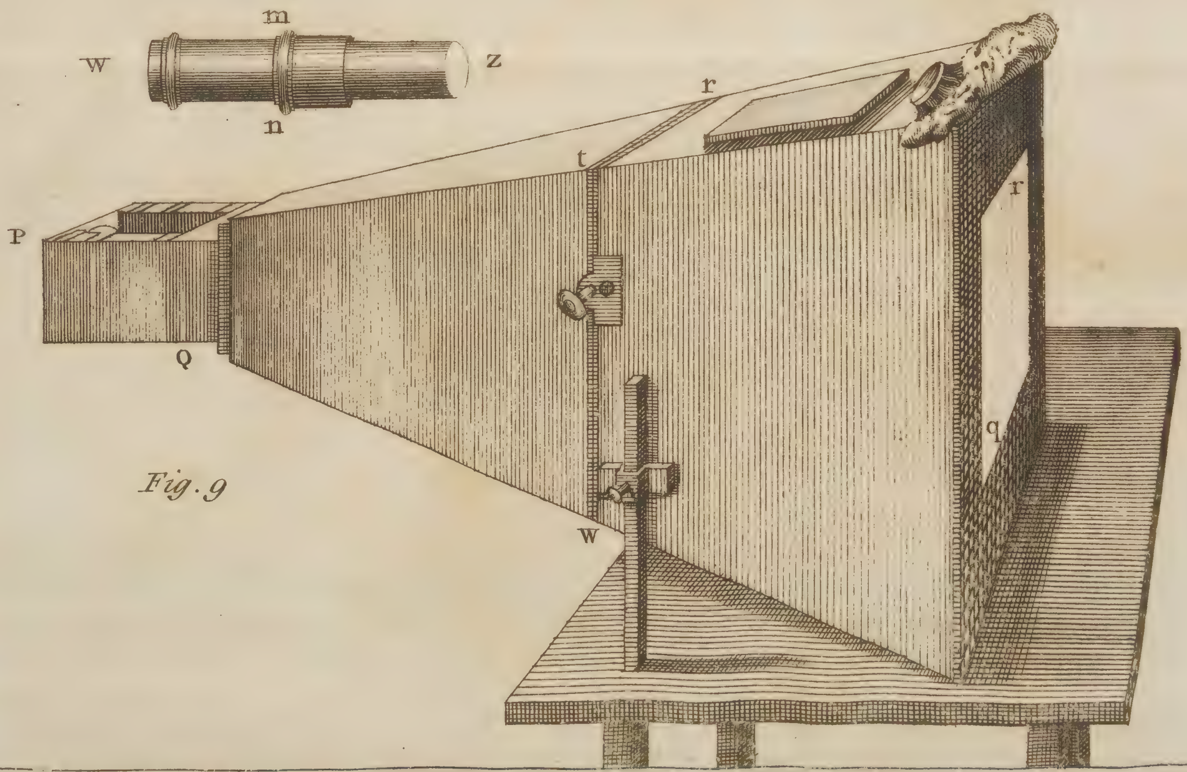

Fig. 9

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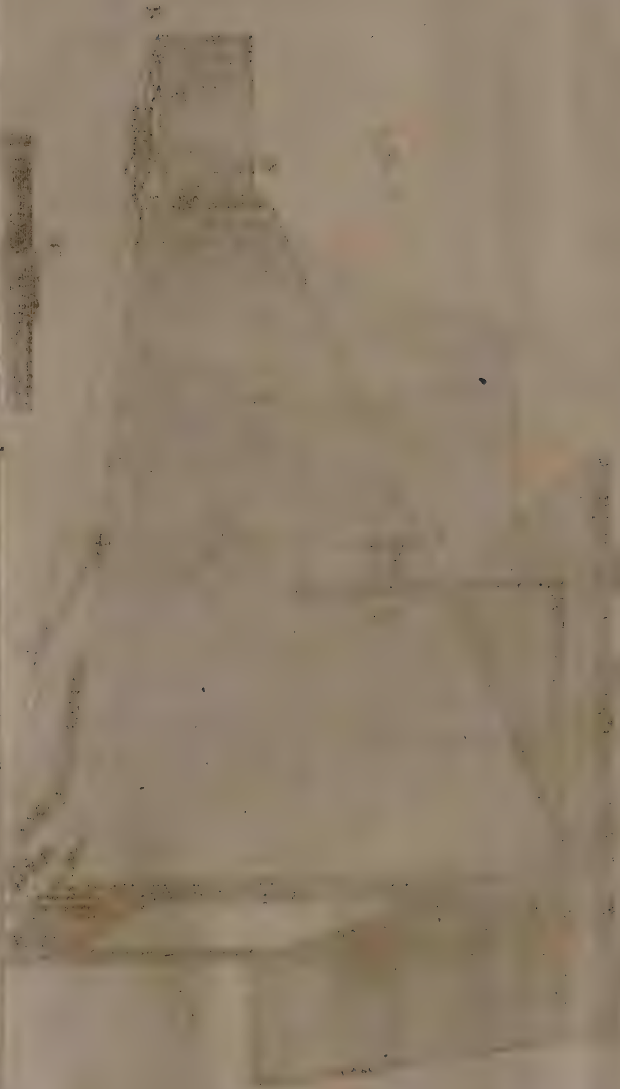


opening, where the face is to be applied: C O E m n, is a ſleeve of cloth; m n, the wriſtband to be buttoned upon the wriſt, when you trace the out-lines of any landſcape.

When you have done with the inſtrument at any time, puſh the ſquare ſliding tube cloſe down; take off the upper part A D w t r, turn the ſmall end downwards, and put it into the lower part r E W. Take off the face piece a b c, put it into the box, and cover the hole it leaves with a ſlider. Puſh in the ſleeve, and cover it with the ſlider prepared for that purpoſe, and the inſtrument will be preſerved from duſt, after you have covered it at the top.

Note, all the ſmall parts may be included in the lower fruſtrum r B, and in the circular head A D K, or they may be packed in a ſeparate box.

The double conſtructed microſcope.

A B C, fig. 10. repreſents the body of this microſcope; it contains an eye-glaſs at A, a broad lens at B, and a magnifier ſet in a button, which is ſcrewed on at C; one of theſe buttons is repreſented by itſelf at Q. There are ſix of them belonging to this microſcope, which are numbered 1, 2, 3, 4, 5, 6, the leaſt number being the greateſt magnifier.

The body of the microſcope A B C, is ſupported by an arm D E, into which it may be put or taken out at pleaſure. This arm being fixed to the ſliding bar F, may be raiſed or depreſſed to any height within its limits, upon the main pillar a b, which being fixed in the box b e, is by means of the braſs foot d, ſcrewed upon the mahogany pedeſtal X r, in which is a drawer at w, containing all the apparatus.

When the upper ſurface of the arm D E, is placed to that number on the fixed bar a b, which correſponds to the number of the magnifier then in uſe, the diſtance of the magnifier from the object will be nearly right, fix it by tightening the ſcrew f, after which you may adjuſt it to fit your ſight, by turning the mild head c of the ſcrew c g.

p q is the ſtage or object carrying plate, with a hole in its center at n; G is a mirror, that may be turned into any direction, ſo as to reflect the light of the ſky, the ſun, or a candle under the object.

H, a convex lens, for illuminating opake objects; L is a cilindrical tube open on each ſide, a concave ſilver ſpeculum h is ſcrewed to its lower end. This cylinder is to be put over the ſnout E C, when an opake object is to be examined, and its upper end ſet to the number of the magnifier in uſe, then the light will be thrown upon it by the mirror G, will be returned back upon that ſide of the object next the eye of the obſerver.

P is a cylindrical tube, in which an inner tube is forced upwards by a ſpiral ſpring. Its uſe is to receive an ivory ſlider K, in which objects are preſerved between two moſcovy talcs, or a glaſs ſlider, upon which any caſual object may be laid: either of theſe are to be put between the plates h and i, and the cylinder P put into the hole n in the ſtage. The hollow at k is to receive a glaſs tube N, in which is confined a ſmall water animal, to ſhew the circulation of the blood: x is a wier ſcrew, to aſſiſt in cleaning the tubes, or to diſcharge their contents.

R a cone to be put on under the bottom of the cylinder P, its uſe is to intercept ſome of the rays of light, when the firſt and ſecond magnifiers are uſed.

S, a box containing a concave and plain glaſs, between which may be confined any ſmall living inſect, which being placed over the middle of the ſtage, may be eaſily examined.

T, a plain circular glaſs to be placed over the center of the ſtage at n, to lay any objects on that may at any time offer, and a looſe concave glaſs of the ſame ſize, being laid with its hollow ſide downwards, will eaſily confine any living inſect.

O, a long ſteel wire with its pliers and point to hold or ſtick objects on, ſlips backwards and forwards in a ſhort braſs tube o, which by the button p, fits into the hole of the ſtage, and then it may be conveniently managed under the magnifier.

W, a little round ivory box to hold a ſupply of muſcovy talcs for the ſliders.

Z, a ſmall hair bruſh to wipe any duſt off the glaſſes, or to apply a drop of any liquid.

X, a pair of nippers to take up any object to be examined.

V, a ſmall ivory cylinder with a hole paſſing through it, one end is black, the other white; it is to be ſtuck upon the point y, of the wire O y: its uſe is to examine opake objects, by placing thoſe of a dark colour on the white ſurface, and thoſe of a light colour on the black ſurface. This piece with the pliers being applied to one of the holes in the corners of the ſtage, and the cylinder L, with the ſilver concave h, upon the ſnout E C, will ſhew an opake object to advantage.

Y, a convex glaſs to be held in the hand, for looking at caſual objects, in order to determine whether they are proper for a microſcopic obſervation.

M, a fiſh pan, whereon to faſten a ſmall fiſh, to ſee the circulation of the blood; its tail being ſpread acroſs the oblong hole at the ſmalleſt end, and tied faſt by means of the ribband fixed thereto, then by ſhoving the knob t through the ſlit m made in the ſtage, the fiſh's tail may be brought under the magnifier.

U is a plain glaſs to lay any caſual object upon, or if it be a living object, cover it with the glaſs T.

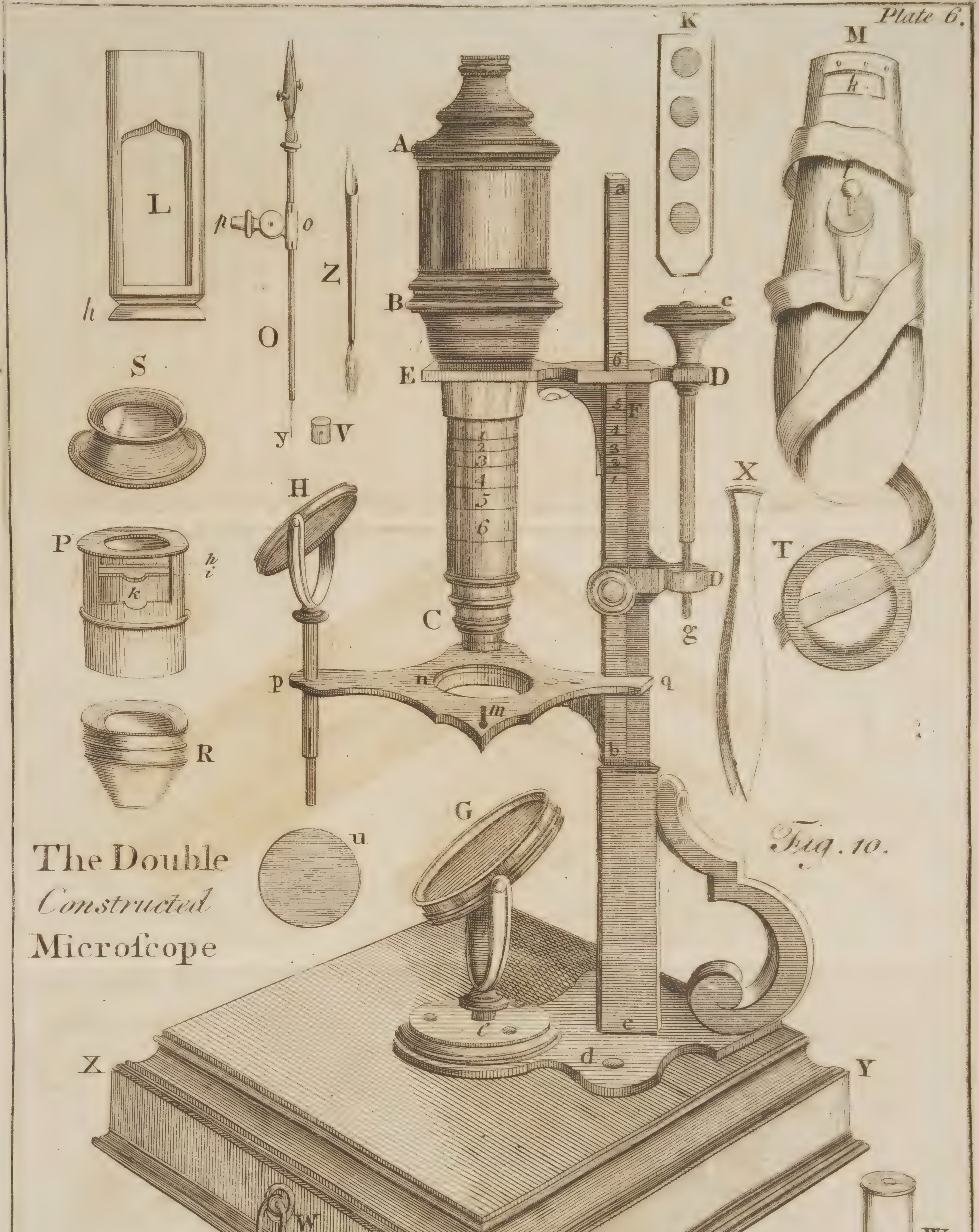
Culpepper's double microſcope.

ABC, fig. 11. is the body of this microſcope, in which ſlides CD the inner tube, that contains all the glaſſes. The eye glaſs is at E, the broad middle plano convex glaſs at F, and the object glaſs being ſet in a button at G, is ſcrew'd upon the end of the narrower tube I, which being fixed in the baſe of the inner tube paſſes freely through a hole in the baſe of the outer.

The buttons that contain the ſeveral object glaſſes are number'd 1, 2, 3, 4, 5, and the convexity of the inner tube, is alſo marked with dotted circles numbered 1, 2, 3, 4, 5, in order to bring that circle to coincide with the mouth of the outer tube, whoſe number is the ſame as that of the object glaſs then made uſe of: but if the object does not then appear quite diſtinct, ſlide, or rather twiſt the inner tube gently, higher or lower, or turn the ſcrew of the magnifier gradually till the object appears diſtinct. The greateſt magnifiers are known by their having the ſmalleſt apertures.

The baſe BC of the outer tube is ſupported by three braſs pillars on ſcrols, fixt on a mahogany pedeſtal HK, in which is a drawer L, to hold the magnifiers and other parts of the apparatus. A little below the object-glaſs is fixed a plate M, like a ſtage between the pillars.

N, three ſmall braſs circles with holes through the middle of them which are to be placed over the hole in the middle of the ſtage, and then the ivory ſlider O may be put between the two uppermoſt, which are preſſed together by a ſpiral ſpringing wire lodged between the two undermoſt. The two outermoſt being held together by four ſmall pillars paſſing through four holes in the circumference of the middle circle.



The Double *Constructed* Microſcope

Fig. 10.

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P, is a fiſh-pan to faſten a ſmall fiſh on, to ſee the circulation of the blood, its tail being ſpread acroſs the oblong hole at the ſmalleſt end; then by ſhoving the button inwards through a ſlit made in the ſtage, a ſmall braſs ſpring under the ſtage will keep it ſteady; for viewing it the tail may be brought exactly under the magnifier, by turning the pan on the button, or by ſhoving it inwards or outwards along the ſlit in the ſtage.

All tranſparent objects are well illuminated in this microſcope, either by candle or ſky-light reflected upwards from a concave looking-glaſs R, placed in a frame upon the center of the pedeſtal. While you are viewing the object through the microſcope, turn this concave upon its horizontal poles a b, and you will ſoon find out that poſition of it wherein it reflects the moſt light through the hole c upon the object.

Opake objects when laid upon the plate s, which is on one ſide black ebony, and on the other a piece of white ivory, being laid over the hole c, in the ſtage, may be illuminated by the light of the ſun-ſhine or a candle tranſmitted through a double convex lens a, which by turning on two ſcrews, e, d, and the foot of it put into the hole f of the ſtage. The candle muſt be placed in a line drawn from the object through the middle of this lens at ſuch a diſtance to be found by trial as will form the ſmalleſt ſpot of light upon the object plate. By daylight this glaſs is of no ſervice.

T, an ivory cone to ſcrew on to a male ſcrew under the center of the ſtage: its uſe is to intercept ſome part of the oblique rays when the firſt and ſecond magnifiers are uſed.

V, a glaſs tube to put a ſmall frog or newt in, to ſee the circulation of the blood. When the object is well expanded on the inſide of the tube, ſlide it over the hole c, in the center of the ſtage; and bring that part of the object you would examine directly under the magnifier.

W, a cell containing a concave and a plain glaſs, is to confine fleas, lice, mites, or any ſmall living objects, and being placed over the middle of the ſtage, may be viewed with eaſe.

X, a plain circular glaſs to be placed over the center of this ſtage to lay any objects on that may at any time offer, and a looſe concave glaſs being laid with its hollow ſide downwards, will eaſily confine any living inſect.

Y, a long ſteel wire with its pliers and point to hold or ſtick objects on, ſlips backwards and forwards in a ſhort braſs tube, which by the button fits into the hole of the ſtage, and then it may be conveniently managed under the magnifier.

O, a flat piece of ivory called a ſlider with four round holes through it, and objects placed in them between muſcovy talcs.

Z, a little round ivory box to hold iſinglaſs for the ſliders.

U, a ſmall hair bruſh to wipe any duſt off the glaſſes, or to apply a drop of any liquid.

J, a pair of nippers to take up any object to be examined.

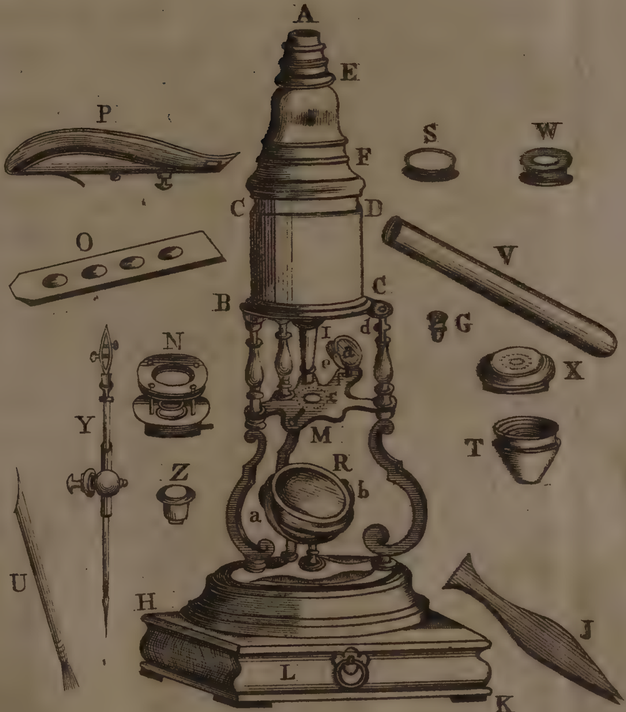
The ſcrew-barrel, or Wilſon's ſingle pocket microſcope.

THIS microſcope of Mr. Wilſon's, is an invention of many years ſtanding, and was in ſome meaſure laid aſide, till Dr. Liberkun introduced the ſolar apparatus, to which he applied it, there being no other inſtrument at that time which would anſwer his purpoſe ſo well; ſince which time it has been revived, and eſteemed, tho' very troubleſome in many caſes.

The body of the microſcope is repreſented by A B, A B, fig. 12. made either of ſilver, braſs, or ivory.

Culpepers double Microſcope

Fig 11



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C C, is a long fine threaded male ſcrew, that turns into the body of the microſcope.

D, a convex glaſs, at the end of the ſaid ſcrew, on which may be placed, as occaſion requires, one of the two concave pieces of thin braſs, with holes of different diameters in the center of them, to cover the ſaid glaſs, and thereby diminiſh the aperture, when the greateſt magnifiers are uſed.

E, three thin plates of braſs, within the body of the microſcope, one whereof is bent ſemicircularly in the middle, ſo as to form an arched cavity for the reception of a tube of glaſs.

F, a piece of wood or braſs, arched in the manner of the ſaid plate, and faſtened thereto.

G, the other end of the microſcope, where a hollow female ſcrew is adapted to receive the different magnifiers.

H, a ſpiral ſpring of ſteel between the ſaid end G, and the plates of braſs E, intended to keep the plates in a due poſition, and counteract againſt the long ſcrew. C.

I, a ſmall turn'd handle for the better holding the inſtrument, to ſcrew on and off at pleaſure.

To this microſcope belong ſeven different magnifying glaſſes, ſix of which are ſet either in ſilver, braſs, or ivory, as in the figure K, and are marked 1, 2, 3, 4, 5, 6. Obſerve the loweſt numbers are the greateſt magnifiers.

L is the ſeventh magnifier, ſet in the manner of a little barrel, to be held in the hand for viewing any larger object.

M is a flat ſlip of ivory, called a ſlider, with four round holes through it, wherein to place objects between two muſcovy talcs.

Six ſuch ivory ſliders, and one of braſs, are uſually ſold with this microſcope, ſome with objects placed in them, and others empty, for viewing any thing that may offer, but whoever pleaſes to make a large collection of objects, may have as many as he deſires.

There is alſo a braſs ſlider, not expreſſed in the figure, to confine any ſmall object, that it may be viewed without cruſhing or deſtroying it.

N, is a forceps, or pair of plyers, for the taking up of inſects, or other objects, and adjuſting them in the glaſſes.

O, a little hair bruſh or pencil, wherewith to take up and examine a ſmall drop of liquid.

P, is a tube of glaſs, to confine living objects, ſuch as frogs, fiſhes, &c. in order to diſcover the circulation of the blood.

When you would view an object, thruſt the ivory ſlider in which the ſaid object is placed, between the two flat braſs plates; obſerving always to put that ſide of the ſlider where the braſs rings are fartheſt from the eye; then ſcrew in the magnifying glaſs you intend to uſe, at the end of the inſtrument G, and looking through it againſt the light, turn the long ſcrew C C, till your object is brought to the true focal diſtance, which you will know by its then appearing perfectly clear and diſtinct. The way of examining any object accurately, is to look at it firſt through a magnifier, that will ſhew the whole thereof at once, and afterwards to inſpect the ſeveral parts more particularly with one of the greateſt magnifiers; for thus you will gain a true idea of the whole, and all its parts. And tho' the greateſt magnifiers can ſhew but a minute portion of any object at once, ſuch as the claw of a flea, the horn of a louſe, or the like; yet by gently moving the ſlider that contains your object, the eye will gradually overlook it all; and if any part ſhould be out of diſtance, the ſcrew C C will eaſily bring it to the true focus.

As objects muſt be brought very near the glaſſes, when the greateſt magnifiers are uſed, be particularly careful not to ſcratch them, by rubbing the ſlider againſt them, as you move it in or out. A few turns of the ſcrew C C will eaſily prevent this miſchief, by giving it room enough.

A ſcrole for fixing Wilſon's pocket microſcope, and reflecting light to it by a mirror.

ABC, fig. 13. is a braſs ſcrole, which, for the better conveniency of carriage, is ſo ordered, as to take into three parts, and put into the drawer upon which it ſtands, with its reflecting mirror, and Wilſon's pocket microſcope.

The top part of the ſcrole is taken off at B, by unſcrewing half a turn of the ſcrew; then lift it up, and it comes out of the ſocket. The lower part unſcrews at C, and the baſe unſcrews at E.

The mirror lifts out at F, which with the ſcrole lie in one partition of the box.

To apply this ſcrole to uſe, fix the body of the microſcope to the top thereof, by the ſcrew A, as in fig. 13. by ſcrewing it in the ſame hole as the ivory handle.

The braſs or ivory ſlider being fixed as before deſcribed, and the microſcope placed in a perpendicular poſition; move the reflecting glaſs D in ſuch a manner, as to caſt the light of the ſky, the ſun, or a candle, directly upwards, through the microſcope; by which means it is made to anſwer moſt of the ends of a double reflecting microſcope, hereafter to be deſcribed.

It is alſo rendered more uſeful for viewing opake objects, by ſcrewing the arm Q R, fig. 12. into the body of the microſcope, at G, then ſcrewing into the round hole R, that magnifier which you think will beſt ſuit your object; and put the concave ſpeculum S on to the outſide of the ring R, you will find in the body of the microſcope, between the wood or braſs F, and the end of the male ſcrew C C, a ſmall hole U, through which ſlide the long wire T, which has a point at one end, and forceps at the other, that may be uſed occaſionally, as your object requires: when you have fixed this, and your object on it, turn the arm R, which is performed by two motions, till the magnifier is brought over the object; it may be then adjuſted to the true focus, by turning the male ſcrew C C, in the ſame manner as before deſcribed. It muſt alſo be turned exactly over the ſpeculum, by twiſting the upper part of the ſcrole to one ſide, till your object, and the two ſpeculums, are in one line, as will be found by trial, and then fix it by the ſcrew B, at which time the upper ſurface of the object will be ſo exceedingly enlightened by the light reflected upward from the mirror, to the concave ſpeculum, as to be ſeen as clear and diſtinct as any tranſparent one.

The manner of applying Wilſon's pocket microſcope to the ſolar apparatus.

THE ſolar apparatus having been already deſcribed, it remains only to ſhew how Mr. Wilſon's pocket microſcope is to be applied to it.

After having fixed the apparatus to the window-ſhutter, and adjuſted it to the altitude and ſituation of the ſun; ſo as to form a round ſpot of light on the ſcreen.

Screw the tube K, fig. 4. into the middle of the plate A A at H, taking care not to alter the looking-glaſs, after it has been adjuſted to form a round ſpot of light as directed before in the uſe of the ſolar microſcope; then ſcrewing the magnifier you chooſe to employ to the end of your Wilſon's microſcope, at G, fig. 12. in the uſual manner, take away the lens D, at the other end thereof, and place a ſlider, containing the object to be examined between the thin braſs plates E.

Things being thus prepared, ſcrew the body of the microſcope A B, by the ſcrew D, fig. 12. to the tube I at M, fig. 4. which ſlides into the tube K, and pull out the ſaid tube I, more or leſs, as the object is capable of enduring the ſun's heat.

The microſcope for opake objects.

A, Fig. 14. is a fixed arm, through which paſſes a ſcrew B, the other end whereof is faſtened to the moveable arm C.

D is a nut fitted to the ſaid ſcrew, which when turned, will either ſeparate or bring together the two arms A C.

E is a ſteel ſpring, that ſeparates the two ſides when the nut is unſcrewed.

F, a piece of braſs turning round in a ſocket, whence proceeds a ſpringing tube, moving on a rivet, through which runs a ſteel wire, one end of which finiſhes in a point G, and the other end hath a pair of plyers R ſolder'd to it; theſe are either to thruſt into, or to take up and hold any object, and may be turned round as required.

I, a ring of braſs, with a female ſcrew fixed on an upright piece of the ſame metal, which turns on a rivet, that it may be ſet at a due diſtance when the leaſt magnifiers are uſed; and ſerves the ſcrews of all the magnifiers.

K, a concave ſpeculum of ſilver poliſhed as bright as poſſible, in the center of which a double convex lens is placed, with a proper aperture to look through it:

on the back of this ſpeculum a male ſcrew L, is made to fit the braſs ring I, which may be ſcrewed into the ſaid ring at pleaſure.

Four of theſe concave ſpecula of different depths, are fitted to four glaſſes of different magnifying powers, to be uſed as objects to be examined may require. The greateſt magnifiers have the leaſt apertures.

M, a round object plate, one ſide white, and the other black, intended to render objects the more viſible, by placing them, if black, upon the white, and if white, on the black ſide. A ſteel ſpring N, turns down on each ſide to make any object faſt; and iſſuing from the object plate is a hollow pipe to ſcrew it on the needle's point G.

O, a ſmall box of braſs, with a glaſs on each ſide contrived to confine any living object, in order to examine it; this alſo has a pipe to ſcrew upon the end of the needle at G.

P, a turned handle of ivory to ſcrew into the inſtrument when it is made uſe of.

Q, a pair of plyers to take up any object, or manage it with conveniency.

R, a ſoft hair bruſh to clean the glaſſes or ſpecula.

When you would view any object, ſcrew the ſpeculum with the magnifier you intend to uſe, into the braſs ring I, place your object either on the needle G, in the plyers H, on the object plate M, or in the braſs hollow box O, as may be moſt convenient according to the nature and condition of it: then holding up your inſtrument by the handle P, look againſt the light through the magnifying lens, and by means of the nut D, together with the motion of the needle, by managing its lower end, the object may be turned about, raiſed, or depreſſed, brought nearer the glaſs, or put farther from it, till you hit the true focal diſtance, and the light be ſeen reflected

Wilſons Microſcope

Fig. 12

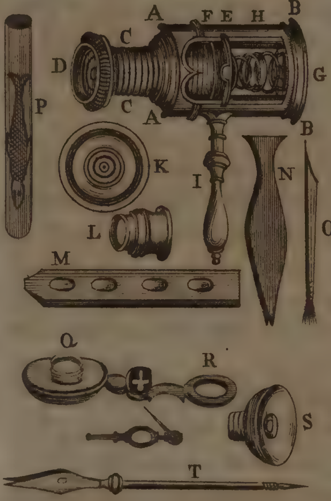
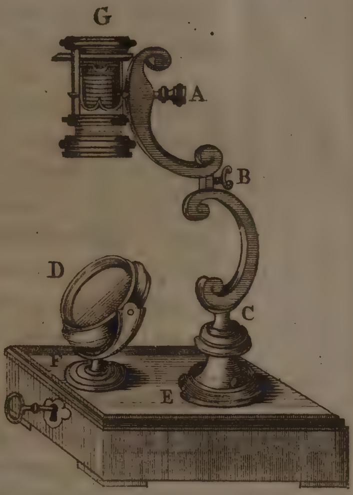
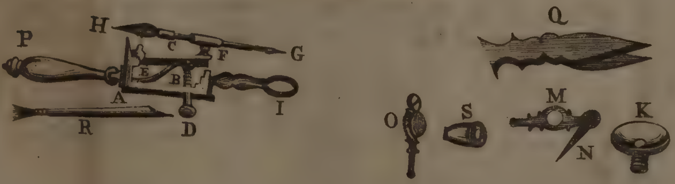


Fig. 13



The Opake Microſcope

Fig. 14



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from the ſpeculum ſtrongly upon the object; by which means it will appear very diſtinct and clear.

The aquatic microſcope, uſed by Mr. Ellis in his diſcoveries on corallines. *

THIS microſcope is very ſimple in its conſtruction, eaſy to manage, and very portable, as it lies flat in the pocket.

A, fig. 15. the braſs pillar that ſcrews into the top of the box K, this box contains the whole apparatus.

H, the ſhank and ſemicircle, in which the concave mirror moves on the two axis, at I, I.

D, the ſliding pillar to adjuſt the ſilver diſh with its lens at F F, to their proper focal diſtance. Note, this pillar D is now made to ſlide through the middle of the pillar A, for the convenience of being put into a leſs compaſs.

G, another ſilver ſpeculum with a higher magnifier.

E, the arm that ſupports the ſilver ſpeculum, is made to ſlide backwards, forwards, and ſideways, ſo as to view all parts of any objects that may be laid upon the ſtage B.

C, a plain glaſs placed on the ſtage, with a black patch upon it for opake objects, and alſo to lay all other kind of objects on, whether they be tranſparent or opake.

M, a watch-glaſs to be placed on the ſtage B, inſtead of the plain glaſs C, for aquatic objects.

L, the nippers pointed at one end for different objects, or to receive on the pointed end the ivory cylinder N, for opake objects.

O, pincers to take up ſmall objects.

P, the bruſh to clean the glaſſes.

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* See Ellis's eſſay towards a natural hiſtory of corallines.

To this microſcope we frequently add a Wilſon's microſcope, fig. 12. to which is fixed an arm like that at E, fig. 15. inſtead of the handle I, fig. 12. by this means we have a more commodious inſtrument than that before deſcribed, fig. 13. of fixing Wilſon's microſcope and reflecting light to it by the mirror, becauſe we have Wilſon's for tranſparent, and this aquatic for opake objects.

But lately inſtead of applying Wilſon's, we have with greater propriety added the tooth and pinnion microſcope, fig. 5. in one caſe with Ellis's microſcope; by which means we have a more convenient inſtrument, that contains the principle apparatus of both, combined into a proper ſize for the pocket.

A ſingle and double aquatic microſcope.

THIS inſtrument has ſome advantages peculiar to itſelf. Fig. 16. and fig. 17. repreſent the principal part of the inſtrument; the firſt ſhews it erect, the ſecond in an inclined poſition.

The magnifiers, No. 6. are to be placed in the ring, f g, of fig. 16.

i, l, k, is the ſtage or object carrying plate, upon which ivory ſliders No. 9. or ſlips of glaſs not expreſſed in the plate, a round glaſs, or a concave glaſs No. 8. may be placed, each of them occaſionally, and agreeable to the object intended to be viewed.

Upon one or other of theſe all objects are to be laid for examination.

r, t, s, is the mirror, to reflect light through any tranſparent object.

When either of the magnifiers is placed in the ring f g, fig. 16. and an object laid upon the ſtage i, l, k, it may be brought nearly to its focus, by diſcharging the ſcrew

Pl 9

Mr. Ellis's Aquatic Microſcope

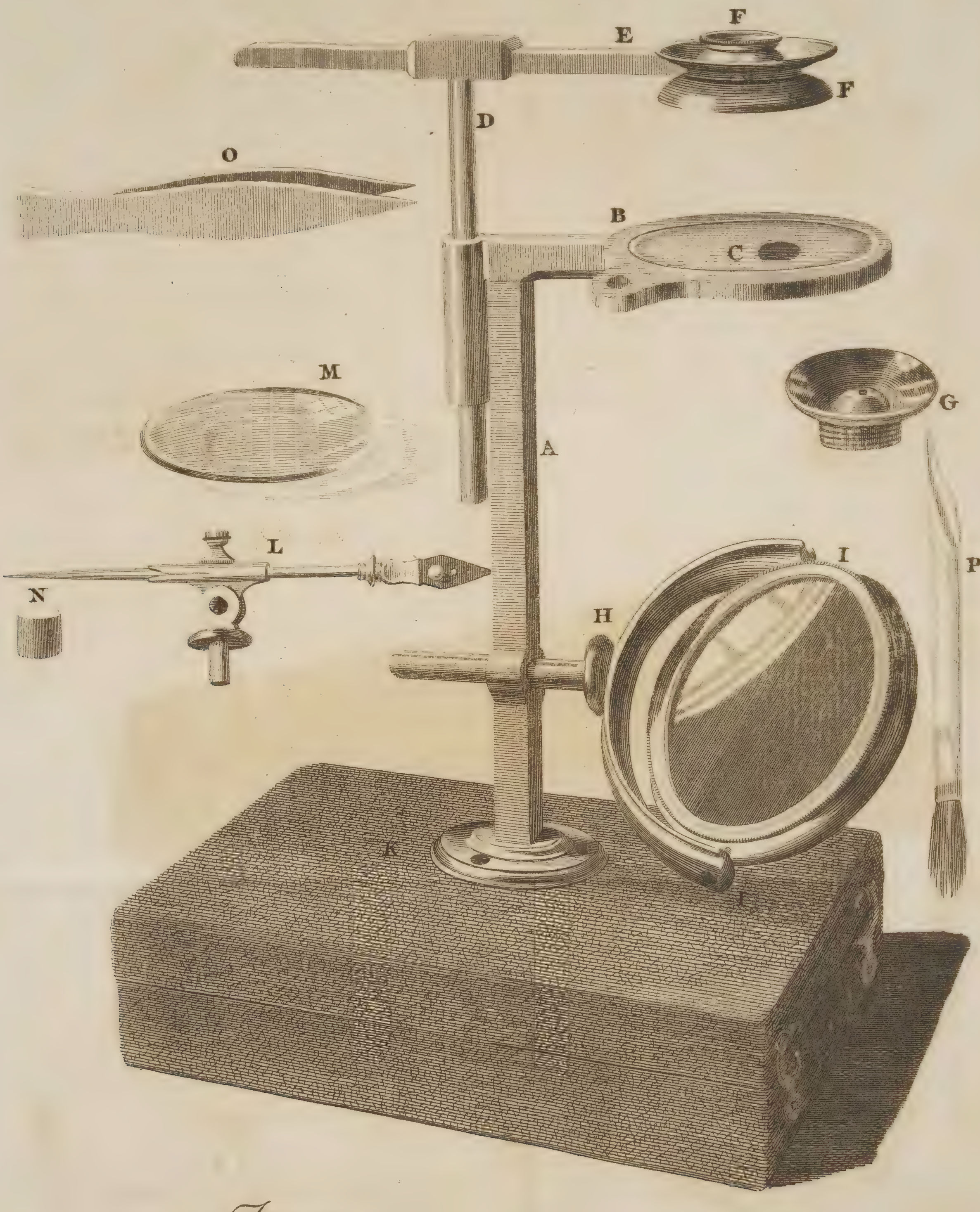

Fig 15

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ſcrew n, and ſliding the bar b, c, higher or lower; then by refixing the ſcrew n, and turning the ſcrew p q, you may obtain the true focal diſtance of the magnifier then applied.

Ivory ſliders and glaſs plates, &c. may be laid acroſs the aperture i l k of the ſtage, when the microſcope is in a vertical ſituation, but when it is inclined as in fig. 17. recourſe muſt be had to the clip b c d, No. 10. its ſhank d, a, is to be put into the ſocket l on one ſide the ſtage, and puſh'd down upon the ſlider, glaſs plane, &c. ſo as to keep it from ſlipping off when the inſtrument is inclined.

A ſmall fiſh or frog may be tied on one of the glaſs planes, or it may be confined thereon by the clip, No. 10. when the circulation of the blood is to be obſerved.

a, b, No. 11. are the nippers pointed at one end for different objects, or to receive on the pointed end the ivory cylinder, No. 12. for opake objects: this is to be applied to the microſcope, by putting the ſtem c, into the hole m, fig. 16.

There are ſix magnifiers to this microſcope; one of them is repreſented at No. 5. another at No. 6. they are to be ſcrewed into the ring, f g.

By means of the ſhank f h, of the ring f g, which ſlides backwards and forwards in the piece h z, and by the aſſiſtance of the joint at z, the magnifier may be brought over any part of the ſtage, l, i, k; the ſcrew at y, will fix the magnifier, when it is found convenient.

There are two ſilver ſpecula to this microſcope, one of which is ſeen at No. 13. each of them contain a magnifying glaſs; their uſe is to illuminate opake objects; theſe are to be ſcrewed into the underſide of the ring, f g.

No. 14. is a little barrel, with a lens to be uſed in the hand, or ſcrewed into the ring f g.

No. 7. is a body containing two lenſes, by the help of which this inſtrument becomes a compound microſcope, and is to be applied as follows; ſcrew the part a, of the magnifier, No. 6. into the ring f g, of fig. 16. then ſcrew the end e of the body, into the female ſcrew in the upper part of the button which contains the magnifier.

When either of the ſilver ſpecula are applied to the body, No. 7. remove the ring f g, and put in a larger which is amongſt the apparatus in the box. Then ſcrew the double microſcope above, and the ſilver ſpecula underneath it. The body of the microſcope may be lengthened, by putting up the tube a b, out of its caſe c d.

No. 16. is a hair pencil to clean the glaſſes, and No. 17. a pair of forceps to take up any ſmall object; the ſcrew No. 4. is to fix the oval plate A B C, to a wooden foot, by the hole at D; or it may be ſcrewed to a table by the other ſcrew No. 4.

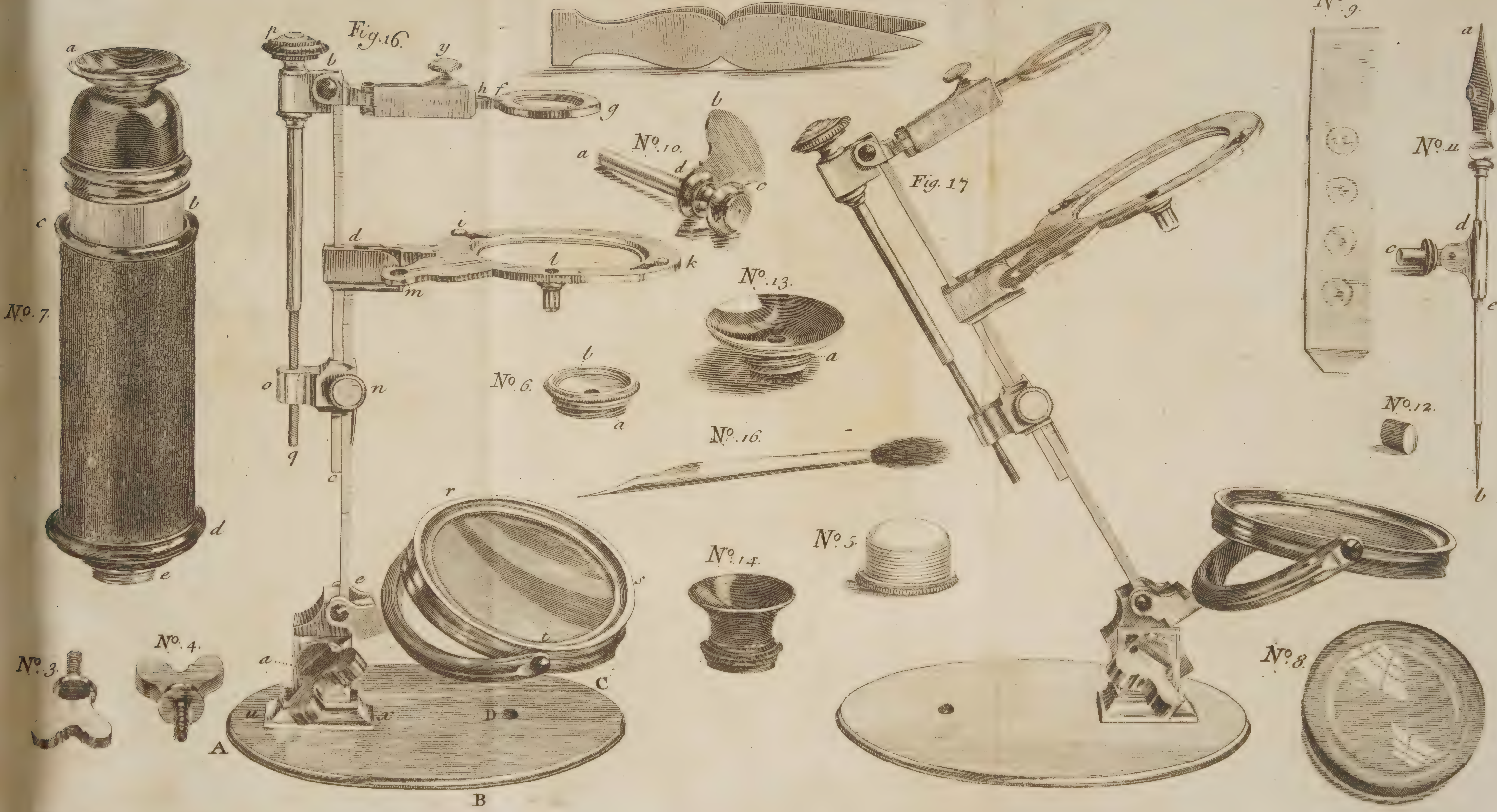
The univerſal ſingle microſcope.

FIG. 18. When it is firſt taken out of its box, the two legs A, B, are to be turn'd about upon joint C, till they make an equilateral triangle with the fixed leg D, then will the pillar E, be ſupported in a perpendicular poſture.

F, is an illuminating glaſs, for reflecting the light of the ſky, the ſun, or a candle, upon the object: its ſupport H, is to be put into a hole, in the center of the round piece G.

The object-bearer I, with its ſprings b, and ſlider K, has a ſquare ſtem behind the ſlider, which is to be put into the hole at L, in the upright pillar E.

The Single and Double Aquatic Microſcope



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M M M, is a ſcollop'd plate, which contains the ſix magnifiers, numbered from 1 to 6, the leaſt number being the greateſt magnifier; in the center, and on the underſide of this plate, is a ſhort cylinder, with a ſmall ſteel pin near the end of it. This cylinder is to be placed in the top of the pillar E, in ſuch a manner that the aforeſaid ſteel pin may go into the ſlit at æ.

N, a black eye piece, hollowed out to defend the eye from the ſide rays of light, under which the magnifiers may be turned round at pleaſure.

O, is a reflecting ſpeculum of ſilver highly poliſhed; which when an opake object is to be viewed, muſt be placed under the eye-piece N. By which means, the light thrown upon it from the mirrour F, will be by it collected and reflected back again upon that ſurface of the object next the eye; which will then be ſo ſtrongly illuminated, as to be examined with eaſe and pleaſure.

P, is an adjuſting ſcrew, by the turning of which an object placed between the object carrying plate I, and ſprings b, is readily raiſed or depreſſed; until it is brought into the exact focus of the magnifier.

1, 2, 3, 4, 5, 6, are marks on the pillar E, to ſhew the reſpective diſtances of the object from the magnifiers, according as each glaſs magnifies more or leſs.—For inſtance, if you uſe the 5th magnifier, firſt place it under the eye-peice N, and then with your finger and thumb turn the ſcrew P, till the finger of the hand which is engraved on the ſliding-piece Q, points to the mark 5 on the pillar; then will the object be very near its exact diſtance from the magnifier; ſo that by a turn or two of the ſcrew P, either backwards or forwards, to be found by trial, you may ſoon fit it exactly to your eye.

The object carrying plate I, and ſteel ſprings b, are capable of holding ivory ſliders, or other contrivances of different thickneſſes, by unſcrewing the little ſcrew c, and with your nail preſſing down the ſlider K, by the button d, the ſteel ſprings will then be ſo ſeparated from the plate I, as to receive any other part of the apparatus; and may be there made faſt by tightening the ſcrew c.

e, A nut, by the ſcrewing of which the joint C may be tightened, if at any time it ſhould wear eaſy.

The plate mark'd fig. 19. repreſents the apparatus belonging to the univerſal ſingle microſcope; and alſo to the univerſal double microſcope, repreſented at fig. 20. Whereof,

a, b, f, Is a contrivance to confine a ſmall fiſh, by putting its tail under a ſpring on the inſide at c, and tying the body of the fiſh to the long part b, f, the two extreme ends of the tail may be drawn through the ſlits d, d, on each ſide, that the middle of the tail may lie flat; then put the end æ of this fiſh-pan between the object carrying plate I, and ſprings b, of fig. 18, (they being firſt opened to a proper thickneſs to receive it,) in ſuch a manner, that the hole e, under which the tail of the fiſh is placed, may lie nearly under the center of the hole f, in the object carrying plate I. In this poſition, the circulation of the blood may be examined with eaſe and pleaſure. It may alſo be ſeen in the web between the toes of a frog's hind foot, which is to be placed under the ſpring at c, and its body tyed with a tape to the part b, f.

R, is a piece of glaſs to be placed as occaſion requires, either upon the ſurface of the object carrying plate I, or between it and the ſprings b; its uſe is to hold any accidental object that may offer.

S, S, a jointed ſlider, containing two flat glaſſes, with cavities ſunk in them, deſigned for confining any ſmall object without cruſhing or deſtroying it; and is alſo to be placed between the object carrying plate I, and ſprings b, which muſt be ſet wider to receive it as before directed.

Pl 11

The Universal Single Microſcope

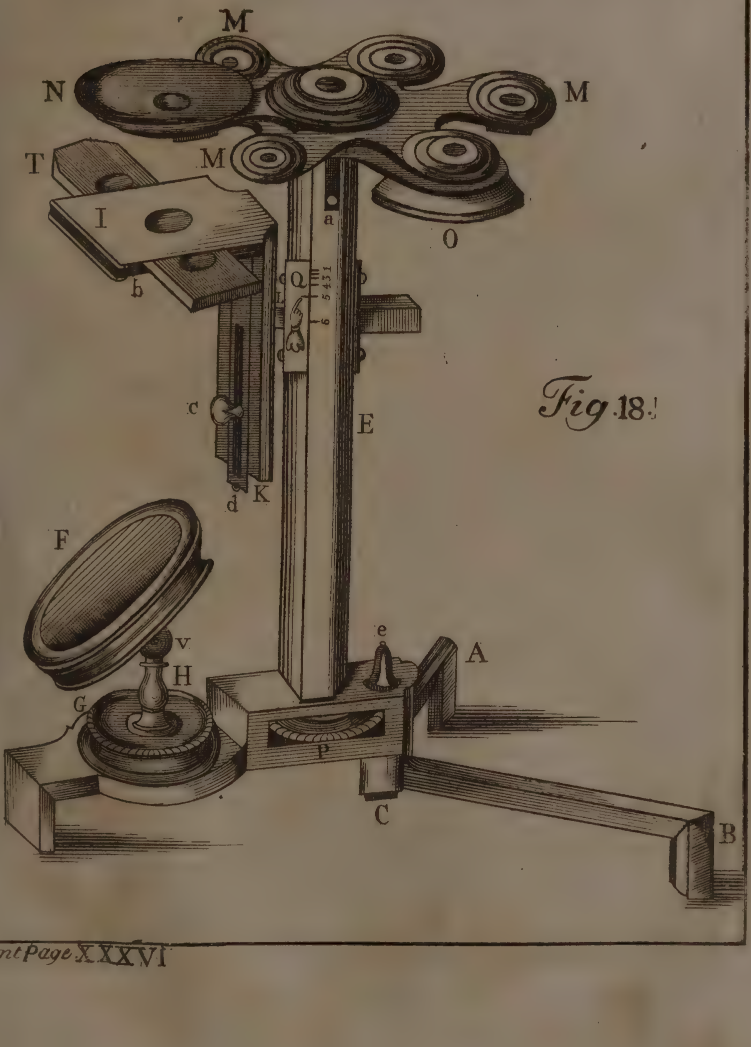

Fig.18.

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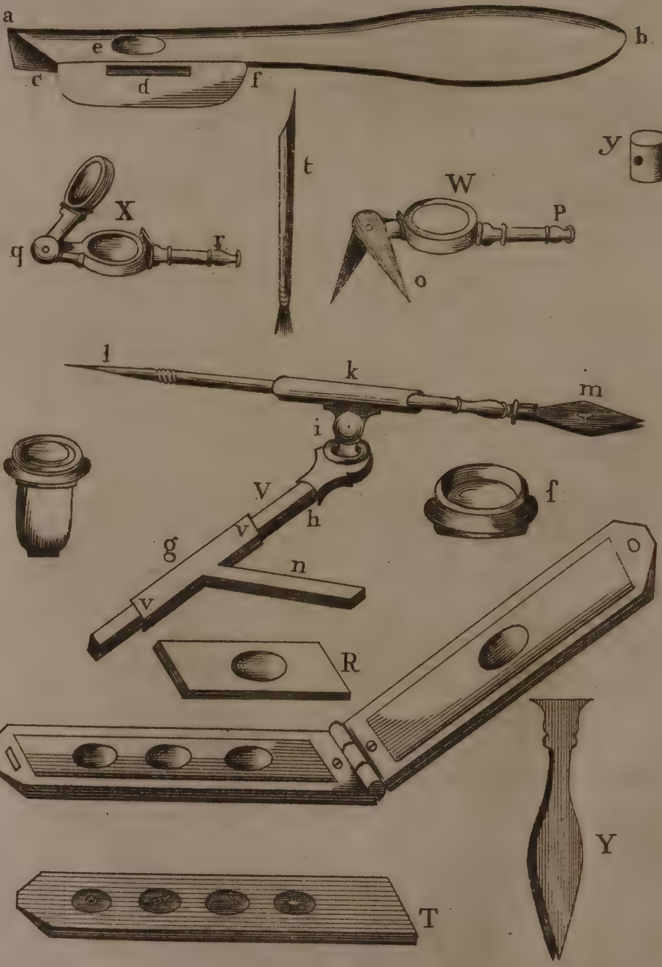
Fig. 19



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T, is an ivory ſlider with four holes, wherein to place different objects between two pieces of muſcovy talcs, and is alſo to be applied between the object carrying plate I, and ſprings b, ſee fig. 18. with the ivory ſlider T, applied to it.

V with its ſocket g, ſliding bar h, joint i, and its ſpringing tube k, through which runs a ſteel wire; one end whereof terminates in a ſharp point l, and the other hath a pair of plyers m, ſoldered to it: the joint i having a twofold motion for the ready placing the parts of an opake object before the magnifier.

When this apparatus is uſed, the ſquare ſtem n, of the ſocket g, muſt be put on to the pillar E, at the hole l, fig. 18. and 20. (the object plate I, with its ſprings b and ſlider K being firſt removed,) it is repreſented as applied to the microſcope at fig. 20.

W is a round object plate, one ſide black and the other white, for rendering objects the more viſible, by placing them if black upon the white, and if white upon the black ſide. A ſteel ſpring o turns on each ſide to make any object faſt, and a hollow pipe p iſſues from the object plate which may be ſcrew'd upon the ſliding wier's point l. y is another black and white object-plate, to be ſtuck on the aforeſaid wire's point for opake objects.

X, is a ſmall braſs box, with a joint at q and a glaſs on each ſide, its uſe is to confine any living opake objects for examination. This box alſo hath a pipe r, to ſcrew over the end of the ſliding wire l.

Y, a pair of plyers or forceps, to take up any object, and manage it with conveniency.

Z, a ſmall ivory box, with iſinglaſs, to be placed when wanted, in any of the ivory ſliders.

ſ, is a ſeventh magnifier, ſet in ivory, to be held in the hand or laid in the black eye-piece N, for viewing any large object.

t, A little hair-bruſh or pencil, wherewith to wipe any duſt from off the glaſſes, or to take up any ſmall drop of liquid one would examine, and to put it upon the glaſs R.

The microſcope being placed on a table near the window, direct the mirror F towards the ſky, and then looking through the eye-piece N upon the object, placed next under the plate I, turn the illuminating glaſs F, ſo about upon its ſupport H, and joint v, till the light is reflected upwards to the object.

When an opake object is to be viewed, place the reflecting ſpeculum O, exactly under the eye-piece N; fig. 18. and fix your object either on the point of the ſliding wire l, in the plyers m, in the braſs hollow box X, or on the object plate W, then apply this whole apparatus mark'd V, to the microſcope, by putting its ſtem n into the hole L of the pillar E, the object carrying plate being firſt removed.

This microſcope may be applied to the ſolar apparatus, by ſcrewing the foot D of the univerſal microſcope. fig. 18. upon the end of the tube M, fig. 4. as before directed, in the deſcription of the ſolar apparatus.

The univerſal double microſcope.

THIS microſcope fig. 20. is compoſed of three double convex lenſes, two of which are placed in the body thereof at a and b, and the magnifier at g, ſix of which belongs to this microſcope, and are fixed in a ſcollop'd plate M, M, M, moveable about a center at f, by which means either of them may be readily turn'd under the other two glaſſes, as at g, whereby the trouble of ſearching out for different magnifiers is remov'd.

The body of the microſcope is ſupported by the arm T, having a circular collar, whereinto it may be ſcrewed,

Pl. 13

The Universal Double Microſcope

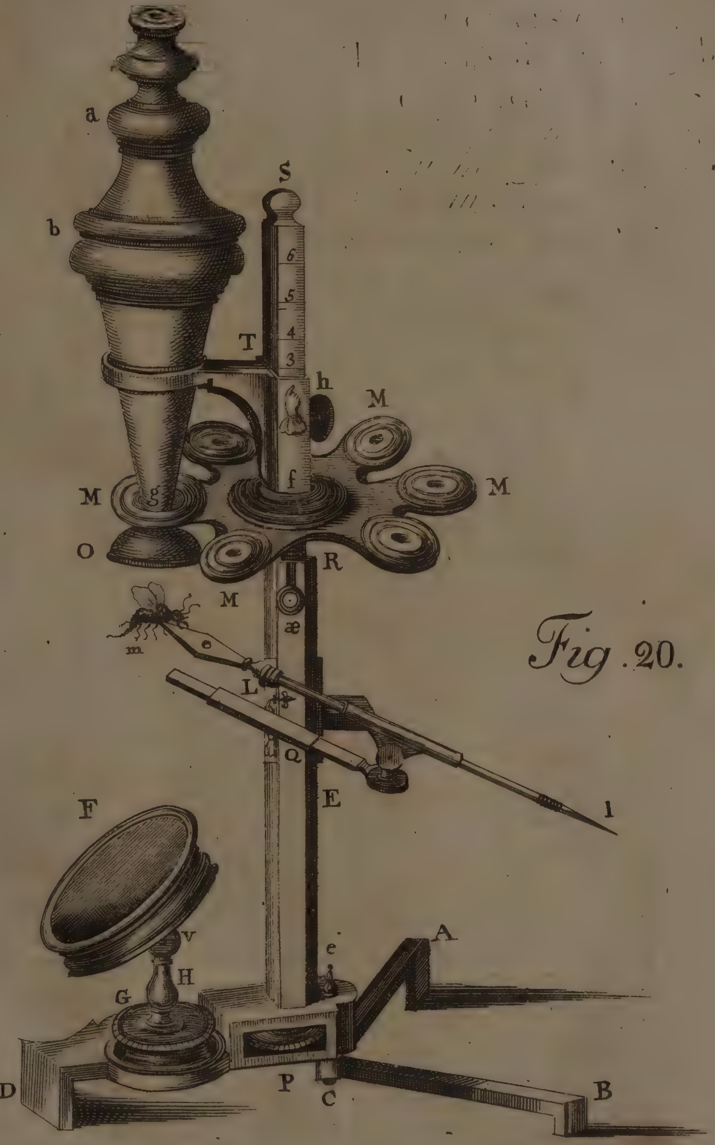

Fig. 20.

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T. Bowles ſc.

ed, or from whence it may be eaſily taken; this arm proceeds from the upper part of the ſliding ſocket T, f.

The aforeſaid ſocket T, f, together with the ſcollop'd plate M M M, and the body of the microſcope, may be moved up or down the ſquare bar R S, which is divided into as many parts (1, 2, 3, 4, 5, 6.) as there are magnifiers of different foci; ſo that the diſtance of the object from the object-glaſs may be found without any trouble, by ſetting the finger of the hand engrav'd upon the ſocket, to the correſpondent number of the magnifier (the nunder the body of the microſcope) on the bar R S, and fixing it there by help of the ſcrew h. But as it is ſcarce exactly enough determined this way, the object may be brought nearer to, or removed farther from the magnifier at diſcretion, by a turn or two of the ſcrew P. Remembering at the ſame time, the upper hand is ſet to any number on the ſquare bar, to place the index on the piece Q, to the flower-de-luce on the upright pillar E.

O, is a reflecting ſpeculum highly poliſhed, which muſt be placed at R, when an opake object is to be viewed, on which a direct light becomes reflected from the aforeſaid ſpeculum.

The ſquare bar R S, fits into the top of the upright pillar E, and may be made faſt thereto by the ſcrew at æ.

The object-bearer I, ivory ſlider, illuminating glaſs F, with its ſupport H, and round piece G, and the apparatus V, with its nippers and ſliding wire, &c. having been ſufficiently deſcribed in the uſe of the ſingle univerſal microſcope, I ſhall refer the reader to that for the uſes thereof, and alſo for a deſcription of the apparatus, which is exactly the ſame as that repreſented in fig. 19. and its uſes and application to this univerſal double microſcope, the very ſame as in the foregoing univerſal ſingle one.

A new compendious pocket microſcope.

THIS inſtrument being an abridgment of the variable microſcope, is contrived for the pocket, that it may be ready when gentlemen and ladies are amuſing themſelves in their gardens, parks, &c. to inſpect, and collect ſuch objects as may be proper to preſerve for a future examination, to be viewed in the variable microſcope, fig. 1. and 2. or to delineate them by help of the camera microſcope, fig. 6. or 7. either in the ſun ſhine, or in long winter evenings.

A B C, fig. 21. No. A. repreſents the body of the microſcope, containing two eye glaſſes at A, a third at B, and a fourth glaſs between B and C, at the end C, is ſeen the dove tail into which the braſs ſlider F that contains the ſix magnifiers, is to be put. The numbers 1, 2, 3, &c. being placed at the extremity of the dove-tail at C, the magnifiers correſponding to each number, will then be under the center of the body of the microſcope, the leaſt number is the greateſt magnifier.

This microſcope in its compound ſtate has the property of increaſing the field of view and the light; as has been ſhewn in page ii. in the deſcription of the variable microſcope, as well as that of increaſing the magnifying power of each particular magnifier.

The compound body A B C, is ſupported by an arm N O, into which at C, it may be ſcrewed or taken out occaſionally. This arm N O, ſlides backwards or forwards into the box P, which turns round on the top of the moveable pillar R, by which double motion every part of an object of the ſize of the ſtage D D may be readily examined.

The ſliding bar R may be raiſed or depreſſed by turning the ivory head I, ſo as to adjuſt the body of the microſcope with either of its magnifiers to their proper focus. This ſliding bar R being connected with the bar X S, that is moveable upon a joint at S, the microſcope may be thereby placed to any convenient oblique ſituation. W,, is a key to tighten the joint at S, if requiſite.

The joint at S turns horizontally in the center z of the triangular feet V V V, which ſupport the whole inſtrument.

The ſtage D D ſlides into a dove-tail at e, in this the ivory ſliders G are to be placed to examine ſuch objects as are placed between the talcs; or all caſual objects may be placed upon the flat glaſs K, when put into the ſtage, and examined with eaſe, or if they be animalcula in fluids, the concave glaſs L is to be applied to the ſtage D D, or if they be living inſects, ſuch as flies &c. firſt place the concave glaſs L upon the ſtage, and cover it with one of the flat glaſſes K, and you may examine it with pleaſure.

Many objects may be viewed by being pinched in the nippers b, the ſtage D D being firſt removed, and the part d of the nippers b with its joint c, being put into the dove-tail at e: the whole of ſuch objects may be turned round, and every part of them examined with pleaſure.

The illuminating glaſs Q Q turns on the two axis n, n, and alſo at f, by which means it may be readily directed to a white cloud and reflect the light under any tranſparent object to the eye at E, and alſo to either of the concave ſilver ſpecula M when an opake object is to be examined that the light may be thrown on that ſurface of the object which is next the eye.

When an opake object is to be examined, unſcrew the dove-tail piece at c, and ſcrew one of the ſilver ſpecula M into its place; lay your object on one of the round glaſſes K or L, or place it upon the ivory cylinder at r, one ſide of which being black, the other ſide white, for a contraſt to any object that may offer.

T, is a pair of forceps to take up any ſmall object.

Remove or unſcrew the body A B C, and ſcrew in its place the black eye-piece H, and you will have an excellent ſingle microſcope to be uſed with all the above apparatus already deſcribed.

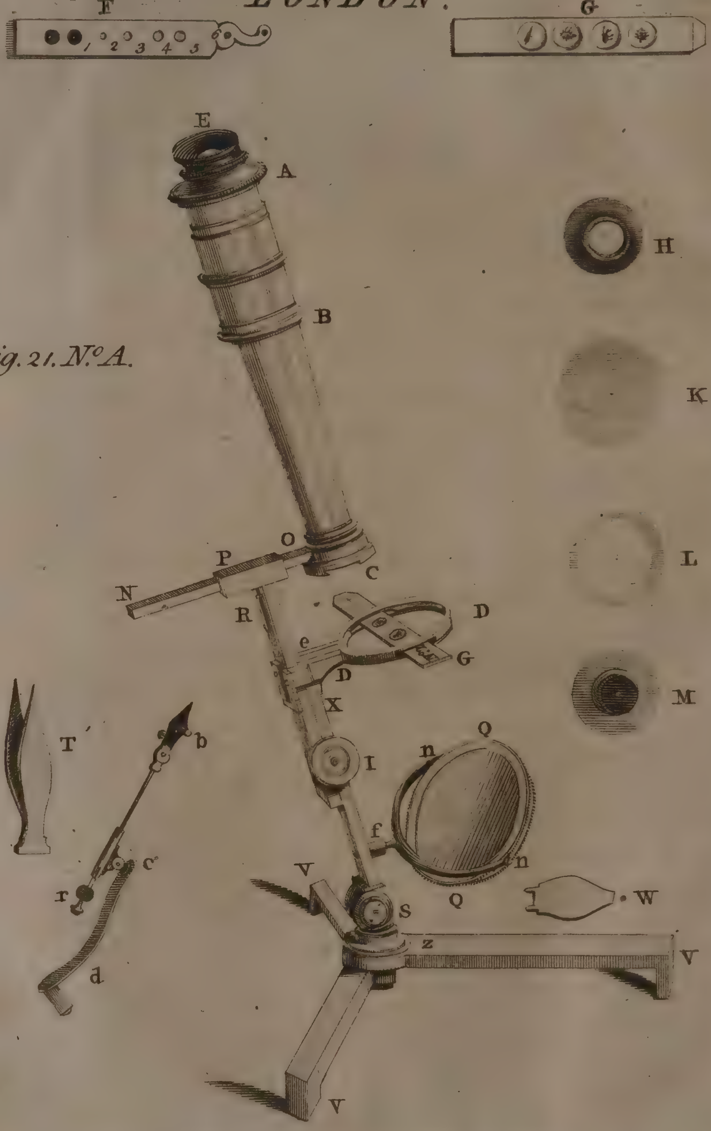
Pl. 14. N° A.

A New compendious Pocket Microſcope.

By Geo. Adams *N° 60 Fleet Street,*

LONDON.

Fig. 21. N° A.



Goodnight sculp.

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To chuſe, prepare, preſerve, and apply objects to the microſcope.

WE muſt be very curious in chuſing ſuch objects as are proper for the microſcope, which are either ſmall parts of larger bodies, or exceeding ſmall inſects, ſalts, ſands, ſeeds, farina of flowers, &c. or the interſtices between the ſolid parts of bodies, as minerals, ſhells, the air veſſels in vegetables, pores in the bones, ſkin, &c. of animals, or the motion of the ſeveral parts of minute animals, or of the fluids in animal or vegetable bodies.

The greateſt care imaginable ſhould be taken in preparing objects for an examination; otherwiſe the beſt ſkill'd in magnifying glaſſes may be miſled, if they give too ſudden a judgment on what they ſee, without aſſuring themſelves of the truth by repeated experiments.

If objects are flat and tranſparent, the beſt method is to incloſe them between two muſcovy talcs, in an ivory ſlider, as the farina of flowers, ſcales of fiſhes, wings of butter and other flies, &c. the bodies of minute inſects, &c. By this method, every virtuoſo may always have ready two or three dozen of theſe ivory ſliders, furniſhed with the moſt curious objects; which will be a moſt delightful natural hiſtory of the ſurprizing beauty, perfection, and contrivance, we find in the works of nature.

In collecting objects for the ivory ſliders, care ſhould be taken to put thoſe into the ſame ſlider, which are of the ſame degree of tranſparency and ſize; that they may all be viewed with the ſame magnifier. There is a convex glaſs of about an inch focus to hold in the hand, in the caſe with moſt microſcopes, by the help of which you may adjuſt the objects properly between the talcs, before you fix them down with the braſs rings; the number of the magnifier may be alſo marked on each ſlider its objects are fitteſt for. Many ſmall living objects may be placed in this manner between the talcs, ſuch as mites, or any other ſmall inſects which will remain alive ſeveral days. But for preſent examination, theſe, as well as larger objects, may be laid in the hollow of a glaſs ſlider, and that covered with a flat glaſs ſlider, or they may be pinched in the nippers, or ſtuck upon the point as occaſion may offer.

The animalcula in fluids, may be examined in a ſmall drop of water taken up with the head of a pin or a hair pencil, and placed in the hollow of a glaſs ſlider; if on viewing them, you ſhould find them exceeding numerous (as is often the caſe,) that by their continual running over one another, their ſhape cannot be diſtinguiſhed, ſome part of the drop muſt be taken off the glaſs, and a little fair water put to the reſt, which will ſeparate, and make them appear diſtinct. It is neceſſary thus to dilute, with fair water, the ſemen maſculinum of all animals; otherwiſe their ſhape cannot be diſcovered, they are ſo crowded together in ſuch infinite numbers.

If ſalts in fluids are to be viewed, you muſt let the fluid evaporate, that the ſalts may be left behind upon the glaſs, and be more eaſily examined.

For viewing the circulation of the blood in the tails of fiſhes, in frogs, newts, &c. they are ſometimes put into glaſs tubes, or tied upon one of the glaſs ſlips or upon a fiſh-pan which is made to ſome microſcopes, or by the frog frame in the meſſentry of a frog to the higheſt advantage, as will be hereafter ſhewn.

Patience and dexterity are required to diſſect inſects, and view their internal ſtructure, which will be eaſily done with a fine needle and a lancet; if they are placed in a drop of water, their parts will then be ſeparated with eaſe; and the ſtomach and bowels lie plainly (before the microſcope) to be viewed and examined.

Bits of different colour'd glaſs are neceſſary for this purpoſe, to place objects on, becauſe many objects are much more diſtinguiſhable when placed on one colour, than on another. Glaſs tubes of all ſizes are likewiſe of uſe, from one-half of an inch bore to a fine capillary.

Opake objects may be preſerved in a box divided into cells, each containing a few ſlips of card, &c. on which the objects are glued with ſtrong gum water, or mouth glue; and if theſe little ſlips are ſtained with ſeveral colours, which may give a contraſt to that of the object, it will be ſeen to the beſt advantage.

All other ſorts of little crawling animals, which are ſo very ſmall that one can hardly touch them without deſtroying their lives, are beſt glued as it were upon the point of a fine ſewing needle, firſt dipped in turpentine. (The needle being firſt made faſt to the end of a ſhort bit of ſtick by way of handle to it.) If you do but juſt touch the back or ſide of any one of theſe minute animals therewith, it will ſtick ſo faſt thereto, as not to be able to remove itſelf; by which means they may be examined with eaſe and pleaſure. The ſewing needle muſt be held between the nippers, and ſo placed before the magnifier, that any part of the animal may be turn'd before the microſcopic lens, by twiſting the handle of the ſewing needle, as you find occaſion.

Hairs, wings of flies, ſmall feathers of birds, &c. are beſt perceived, and eaſieſt examined, when placed between two muſcovy talcs in an ivory ſlider.

A method of meaſuring objects that are viewed in compound microſcopes.

THE general practice being formed under the conſideration, that a perſon of a common ſight ſees objects diſtinct at about eight or ten inches diſtance from his eye, let us ſuppoſe ten inches; if the ſame perſon looks upon the ſame object with a lens of one and 1-quarter inch focus, he will ſee this object eight inches nearer to his eye; and as the angle formed by the image on the retina, appears eight times greater, ſo knowing the focus of any ſmall lens, it will be eaſy to find how much the appearance of the object is magnified, by finding how many times its focus is contained in eight or ten inches, &c. but as this method is doubtful in ſeveral reſpects, we ſhall only mention the difficulty of coming at the preciſe focus of a very ſmall lens; and alſo obſerve, that thoſe who are ſhort-ſighted, cannot comply with a baſe of eight or ten inches for their calculations; and thence proceed to the following eaſier method.

All convex lenſes of any focus, have the property of doubling the apparent diameter of an object, and conſequently of quadrupling the ſurface, * provided the object is at the focus of the glaſs on one ſide, and the eye in the oppoſite focus on the other ſide.

Take a double convex lens of eight or ſix inches focus, fig. 21. and fix it at A, perpendicular to a rule FG, divided into inches and parts upon a ſliding piece at B; ſtick a piece of white paper as at D, two or three tenths of an inch broad, and three inches long, on which draw three black lines which ſhall divide the breadth into four equal parts, and obſerve that the middle

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* Journal Œconomique pour le Mois d'Aout, 1753.

dle of this paper correſponds to the center of the lens; an eye-piece E muſt alſo ſlide upon the rule. Being thus prepared, go into the darkeſt and moſt remote part of a room from the window, and direct the glaſs A towards any remarkable object without doors, and move the ſliding piece B, until the focus is determined upon by the rule, by a diſtinct repreſentation of the object; count the inches and parts between the edge of the ſlider B, and center of the lens at A, and ſlide the ſight E on the other ſide of the lens to the ſame diſtance, this will give the double focus.

Place one eye cloſe to the ſight at e, and with the other eye look at the object D; you will then find the image ſeen through the glaſs A, and expreſſed by the dotted lines, to be double the breadth of the ſame image ſeen at the ſame time by natural viſion; this holds good whatſoever the focus of the lens may be with which you make the experiments: the ſame proportionable diſtance being attended to between the eye and the lens, and from thence to the object, the breadth of the object will always be double to that ſeen by the naked eye.

In fig. 22. Let the angle A F B, be equal to that made by the naked eye without a glaſs, from the rays of light, paſſing by the extremities of the object till they unite in the eye at the point F.

The angle D F E, is equal to that which firſt came parallel from the ſides of the object A B, to I K, from whence they were refracted through the lens to the point F its focus.

C O, is equal to the focal diſtance of the lens on the ſide next the object; c F equal thereto on the ſide next the eye F O, the diſtance between the eye and the object.

It is evident the naked eye would ſee the object from the point C, of double the ſize it would appear if viewed from the point F; as the diſtance F O, is twice that of

C O, we muſt prove the angle A C B, to be equal to that of I F K.

The optical axis F O, being perpendicular to the glaſs and ſurface of the object, the parallel rays A I, B K, flowing from the points A and B in their progreſſion towards the eye, are alſo perpendicular thereto, until they arrive at the lens, where they project the diameter of the object at I K: hence F C=C O and I K=A B, the two triangles A C B, I F K, will be ſimilar, and thence the two angles at the points C and F, equal; but the viſual rays F I, F K, continued to the ſurface of the object D E, will form the angle D F E, equal to the firſt angle A B C; therefore, as C O: AB : : F O: DE, whence it is plain, that the diameter of the object, appears double the ſize when ſeen through the lens, than when it is viewed with the naked eye, and conſequently quadruple in ſurface.

No notice has been taken of the double bending of the rays in their paſſage through the lens, it being a natural effect, has no weight in the demonſtration, as appears from the line S S, which is in the direction of the paſſage of the rays through the lens, whence it may be ſuppoſed the rays bend only on the line G H.

On the removal of the eye from F to M, half the focal diſtance, the apparent diameter of the object will only be magnified one third.

On the contrary, if the eye be removed from F to N, double the focal diſtance; the diameter of the object will appear tripple: whence it is plain, that if the point of ſight be taken at any other diſtance, but the focal point of the lens, the apparent magnitude will be either greater or leſs.

The ſimpleſt method to find the magnifying power of any compound microſcope, is to have a little ebony rule, three or four tenths of an inch broad, about one tenth thick, and ſeven inches long; at each inch is fixed a piece of ivory, about 2-10ths broad, the firſt inch being intirely ivory, is ſubdivided into 10 equal parts. See fig. 23.

A piece of glaſs, fixed in a braſs or ivory ſlider, on which is drawn two parallel lines, acroſs its diameter, about 3-10ths of an inch long; each tenth being divided, viz. one into three, the ſecond into four, and the third into five parts: this is called a micrometer. See fig. 24.

The uſe of theſe are as follow; place the micrometer fig. 24. on the middle of the ſtage, and the rule fig. 23. on one ſide, but parallel to it; then look into the microſcope with one eye, keeping the other open, obſerve how many parts, one tenth of a line in the microſcope takes in upon the parts of the rule ſeen by the naked eye. For example, ſuppoſe with a fourth magnifier, that 1-10th of an inch magnified, anſwers in length to forty tenths or parts on the rule when ſeen by the naked eye; which ſhews that this magnifier increaſes the diameter of the object forty times.

The ſimplicity of this method, gives general ſatisfaction to thoſe who can manage it; but there are ſome people who find it difficult, from their not having been accuſtomed to obſerve with both eyes open, for ſuch perſons another micrometer is provided.

A micrometer for a compound microſcope.

FIG. 28. repreſents this micrometer; it is applicable to the body of any compound microſcope. It was made for his majeſty in the year, 1761, and with it was then preſented a manuſcript of its uſe, of which the following is an extract with ſome alterations.

The ſcrew has fifty threads to an inch, it carries an index, pointing to the diviſions on a circular plate, fixed at right angles to the axis of the ſcrew; its revolutions being counted on a ſcale of one inch, divided into fifty parts.

Thus every revolution of the micrometer ſcrew, determines 1-50th part of an inch, and the circumference of the circular plate, to which the index of this ſcrew points, being divided into twenty equal parts, we have by inſpection any certain number of theſe parts contained in any part of one ſingle revolution of the micrometer ſcrew: by this means we obtain one ſingle thouſandth part of an inch.

To the ſliding piece of this micrometer, is fixed a ſmall needle in ſuch a manner, that its point may traverſe acroſs the field of view, by which means we are enabled to meaſure the length and breadth of the image of any object applied to the microſcope, but not that of the object itſelf, without another aſſiſtance.

This requires an attentive eye to watch the motion of the needle's point, as it paſſes over the image of a known part of an inch placed on the ſtage; we acquire a very ſmall part of an inch by help of the following ſcale. Fig. 25, 26, 27. in which the two lines c a, c b, with the ſide a b, form an iſocelles triangle; c a, and c b, being each of them two inches long, and the ſhort ſide a b, exactly 1-10th of an inch. The two long ſides a c, b c, may be of any length we pleaſe, and the ſhort ſide equal in length to 1-10th of an inch; the longer ſides may be ſaid to repreſent the lines of lines, upon a ſector opened to 1-10th of an inch: hence whatever number of equal parts c a, c b, are divided into, their tranſverſe meaſure will be ſuch a part of 1-10th of an inch as their diviſions expreſs. Thus if it be divided into ten equal parts, this will divide the inch into one hundred equal parts, the firſt diviſion next c, will be = 1-100th part of an inch, becauſe it is the tenth part of 1-10th of an inch. If theſe lines are divided into twenty equal parts, the inch will by that means be ſubdivided into two hundred equal parts. Laſtly, if a b, c a, are made about three inches long, and divided into one hundred equal parts, we obtain a diviſion of 1-1000th part of an inch, as in fig. 27. In this figure the breadth a b is 1-10th of an inch, the next diviſion to it is 99-100th parts of 1-10th; or in other words, it is 1-1000th part of an inch ſhorter than 1-10th, and ſo on till you come to the point c.

The firſt of theſe ſcales was drawn on a ſilver bar, in form of fig. 25.

This ſcale has been ſince changed by Mr. Cummins, thus; inſtead of making a ſolid bar in the ſhape of fig. 25. he made a perforation of the ſame ſhape, between the edges of two plates, as in fig. 27. which is more agreeable to the eye, when viewed in the microſcope, the light paſſing thro' the aperture; and in the body of the microſcope to be uſed with this apparatus. At the field of view was placed a circle of 1-6th of an inch diameter, cut on a glaſs plane, which is to be clipped by the inner edges of the ſectoral ſcale, in order to come at the magnifying power of the inſtrument.

But this apparatus, as hitherto applied, is not ſo uſeful as the following, therefore we ſhall proceed to give,

The uſe of the micrometer and ſectoral ſcale, when drawn on glaſs or muſcovy talc.

FIG. 28. repreſents the micrometer which we mentioned before; to place it upon the body of the microſcope, open the circular part F K H, by taking out the ſcrew g, and throwing back the ſemicircle F K which turns upon a joint at K, as may be ſeen in fig. 28. Now turn the upper tube of the body of the microſcope, ſo that the ſmall holes in both of them may coincide to let the needle g of the micrometer have a free paſſage through them, and ſcrew it faſt upon the body by the ſcrew G, paſſing through the two ears F and H, and it will then appear as at X, fig. 1. Place the ſectoral ſcale, fig. 26, which is drawn on glaſs, on the ſtage, and adjuſt the microſcope to its proper focus, or diſtance from the ſcale, which ſlide on the ſtage until the largeſt extremity appear in the middle of the field of view, and bring the needle point, by turning the head L, to touch one of the lines c a, exactly at the point anſwering to 20, the index at a fig. 28, being ſet to the firſt diviſion, and that on the dial-plate, which could not be repreſented in this figure being ſet to No. 20, which is both the beginning and ending of its diviſions. We ſhall then be prepared to find the magnifying powers of every magnifier in any compound microſcope whatſoever, if the above cautions are attended too.

EXAMPLE.

Every thing being prepared as we have directed, and any magnifier, ſuppoſe No. 4, in the firſt table to be uſed, turn the micrometer ſcrew until the point of the needle has paſt over the magnified image of the 10th part of one inch, then the diviſions where the two indices remain, will ſhew how many revolutions and parts of a revolution the ſcrew has made, while the needle-point traverſed that magnified image of 1-10th of an inch, the reſult was twenty-ſix revolutions of the ſcrew, and fourteen parts of another revolution, which is equal to $26 \times 20 + 14. = 534$ thouſandth parts of an inch.

Hence we derive an eaſy way to count the diviſions on the micrometer, thus finding upon the ſtraight ſcale twenty-ſix diviſions while the needle point paſſed over the magnified image of 1-10th part of an inch, which being multiplied by 20, becauſe the circular-plate C D. Fig. 28, is divided into twenty equal parts produces 520, then

Fig. 21

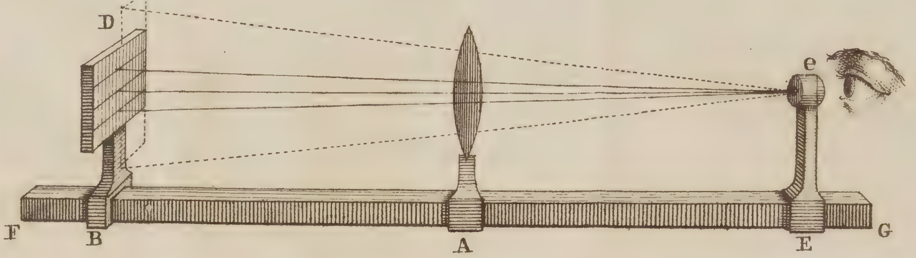


Fig. 24

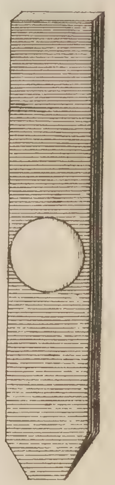


Fig. 22

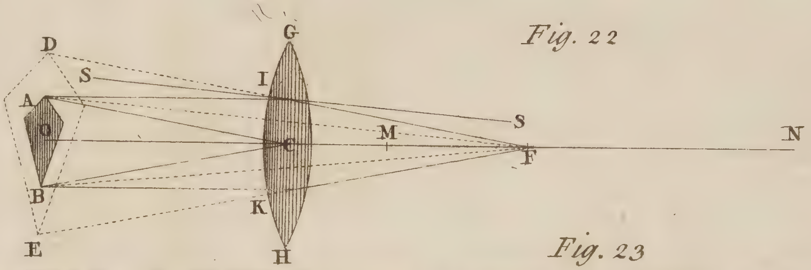


Fig. 23

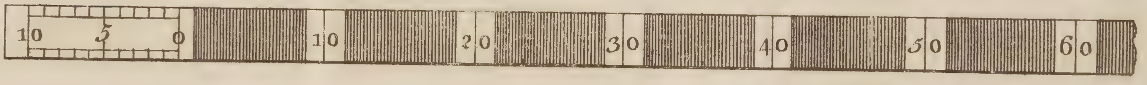


Fig. 25

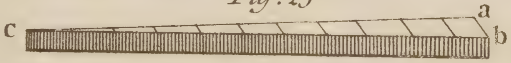


Fig. 26

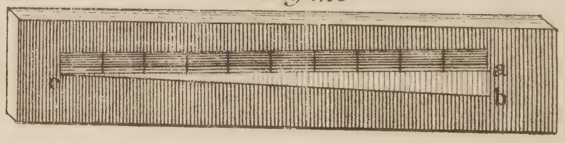


Fig. 27

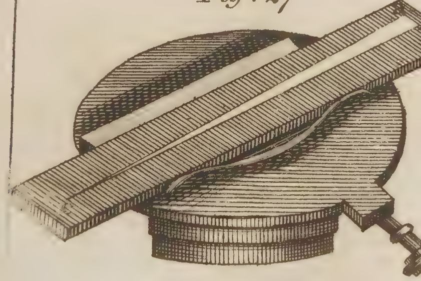
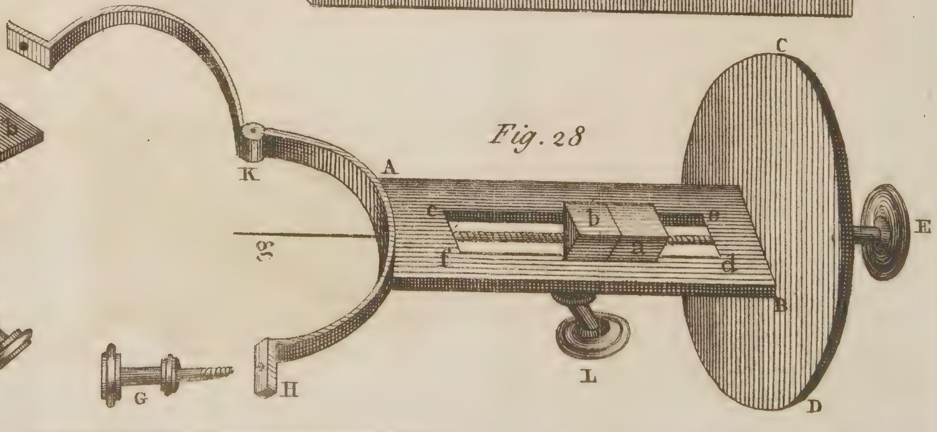


Fig. 28



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Goodnight sculp.

then adding the fourteen parts of the next revolution we obtain the 534 thouſandth parts of an inch, which is the meaſure of the image of 1-10th of an inch magnified at the aperture of the compound microſcope, or rather the field of view to be equal to the meaſure of 5-10ths and 34-100dredths parts of another tenth.

And as we ſuppoſe the compound focus of the two eye-glaſſes in the variable microſcope to be one inch 2-10ths, = 1,20, its double will be equal to 240 thouſandth parts of an inch for the diſtance of the eye from the image, or from the needle-point of the micrometer.—Again, if we take the diſtance of the image, from the object on the ſtage which is 6, 40-100 inches equal to 6, 40 thouſandth parts of an inch, and add thereto 240, double diſtance of the focus of the eye-glaſs, we ſhall have 880 thouſandth parts of an inch for the diſtance of the eye from the object, and from the property of the eye-glaſs in doubling the image, we muſt alſo double the number 534, found upon the micrometer which makes 1068, then by the following analogy, ſay;

As 240, the diſtance of the eye from the image, is to 880, the diſtance from the eye to the object : : ſo is 1068, the double of the meaſure found on the micrometer, to 39,16 the number of times the microſcope magnifies the diameter of the object.

Having thus obtained the magnifying power of all the magnifiers when applied to the compound microſcope, by ſhewing how much the object is magnified; the next ſtep to be conſidered is to calculate a table of the powers of every ſingle object lens, of the particular microſcope the reader may be poſſeſſed of, becauſe it is almoſt impoſſible to work two deep magnifiers, that ſhall be preciſely of the ſame focus; therefore the table I have here ſubjoined, will not anſwer every microſcope, but may nearly anſwer the variable microſcopes which I make.

The above analogy will anſwer to every compound microſcope, but the reſult will not be the ſame.

The next enquiry is the minuteneſs of the object itſelf, which requires a table ſhewing the apparent ſize of objects ſeen under the various revolutions and parts of a revolution of the micrometer ſcrew; to perform this,

Put on any magnifier, as No. 4, and the ſectoral glaſs-ſcale on the ſtage, raiſe or depreſs the microſcope till the object appears diſtinct, meaſure the diſtance from the ſtage, to the hole, thro' which the needle enters the body of the microſcope, then apply the micrometer, and adjuſt the point of the needle to the edge of the field of view, count how many whole revolutions the micrometer-ſcrew makes in paſſing acroſs the diameter, which we find to be 40, now multiply 40 by 20, (the number of parts the dial-plate is divided into), and we ſhall obtain its meaſure to be equal to 800 thouſandth parts of an inch, its double is equal to 1600.

The meaſure of the diſtance from the ſtage to the needle-point, as found above, being equal to 640, to which adding the double focus of the eye-glaſs = 240, we obtain 880 parts for the diſtance of the eye from the object, then doubling the number found on the micrometer, which is 1600; ſay,

As the diſtance of the eye from the image 240: is to double the meaſure of the feild of view 1600 :: ſo is the mean diſtance of the eye from the object 880: to a fourth number 586,666, which divided by 40, the No. of revolutions of the micrometer-ſcrew, produces 146.666 thouſandths parts of an inch. The two tables follow;

TABLE I.

Revolutions.	The meaſure of any number of revolutions given to any extent on the ſtage.
1	146
2	293
3	440
4	586
5	733
6	880
7	1026
8	1173
9	1320
10	1466
20	2933
30	4400
40	5866

TABLE II.

	MAGNIFYING POWERS.		
	Diameter	Surface.	Solidity.
1	624.85	389376	241970324
2	184.36	32856	6035504
3	69.51	4716	328509
4	39.16	1521	59319
5	26.46	679	17576
6	16.71	256	4096
1	203.25	41209	8365427
2	79.89	6241	493069
3	45.65	1025	46125
4	28.35	784	21952
5	15.92	225	3375
6	12.39	144	1728

The firſt of theſe tables was made from the mean diſtance of all the magnifiers from the ſtage, or in other words the mean height of the needle-point from the object; but as this is done only to ſhew how to form ſuch another ſett of tables, if more exactneſs be required, it may be neceſſary to have three ſuch tables, at leaſt one for the mean height between the two greateſt, one a mean between the two middle magnifiers, and a third between the two ſhalloweſt.

Theſe tables being once made, their uſe is very eaſy; the firſt table of the meaſures anſwering to the revolutions of the micrometer-ſcrew, being expreſſed in the thouſandth parts of an inch, are eaſily read as follows. Oppoſite to 20 revolutions, you find the No. 2933, the firſt fig. 2, is 2 inches, the ſecond being 9, ſhews 9-tenths; and the two laſt figures being 33, are 33 parts of 100, which we have divided each ſingle 10th of an inch into, by means of the micrometer-ſcrew; therefore the meaſure of 20 revolutions, is equal to 2 inches 2-tenths; and $\frac{33}{100}$dreth parts of another tenth.

Again, if you meaſure nine revolutions by the micrometer-ſcrew in the ſame manner, it will be found from the firſt table to be 1320; which is equal to one inch, three tenths, and twenty parts of 100 of another tenth.

Likewiſe in the ſame table 1, where we have but three figures as at five revolutions, which are 733, here the firſt is ſeven tenths of an inch, and the two laſt 33 parts in 100, of another tenth; that is ſeven tenths and $\frac{33}{100}$dredth parts; and ſo of the reſt.

In the column entitled Diameter in the ſecond table, the numbers are alſo expreſſed in thouſandth parts of an inch, ſo that the two laſt figures to the right-hand are decimal parts of one tenth of an inch; the third figures from the ſame hand are tenths, and all the reſt are whole inches. As all theſe meaſures are computed from the number of revolutions of the micrometer-ſcrew, in paſſing over the magnified image of 1-10th of an inch; it is plain, that the numbers in this column which ſtand againſt the number of each magnifier, expreſs the true meaſure of the magnified image.

EXAMPLE.

Againſt the third magnifier which is ſet in a button, we find 6951, this ſhews that one ſingle tenth part of an inch is magnified to the length of ſix inches, 9-10ths, and 51-100th parts of another tenth in length, — we therefore without exaggeration ſay, every object examined with this magnifier, is magnified ſixty-nine times and half, and ſo of all the reſt.

The uſe of the preceeding Tables.

IF the apparent length or breadth of any object be required, meaſure it by turning the micrometer-ſcrew, until the point of the needle has paſſed over that part of the image under conſideration, and you obtain the revolutions agreeable thereto.

EXAMPLE I.

Suppoſe you have 20 revolutions, which in the firſt table anſwers to 2933, this is equal to 2 inches 9-10ths $\frac{33}{100}$dredths; then to find the ſize of the object itſelf, enter the ſecond table with the number of the magnifier in uſe; ſuppoſe the third magnifier, againſt which in the column entitled DIAMETER, you will find 69 51, which ſhews the third number magnifies 69 one half times; this ſhews the diameter of the object to be no more than 1-69th part of two inches and 9-10ths, — whence dividing the number in the firſt table by the magnifying power found againſt the number of the magnifier in the ſecond, the true length of the object itſelf is found to be 42-100th parts of 1-10th of an inch.

If any number of revolutions of the micrometer-ſcrew ſhould happen between 10 and 20, 20 and 30, &c. the meaſure muſt be taken out from the firſt table twice, as follows:

Suppoſe you have 25 revolutions, take out the numbers anſwering to 10 and 5, add them together, and you obtain your deſire; or thus,

Revol.
20 - - 1466
5 - - 733
inch. tenth
Revol. - - 25 - - 2199 its Meaſure = 2 - - 1 $\frac{99}{100}$ths.

EXAMPLE II.

Suppoſe we have 25 revolutions of the micrometer-ſcrew, they will be found equal to 2199, (as we have ſhewn above), which is 2 inches 1-10ths and 99-100 parts of another tenth, and if we apply the firſt magnifier, which is ſett in what is generally called a button, in the ſecond table againſt the firſt number 1, will be found 624.85, we reject the fractional parts, to prevent exaggeration, which ſhews that number 1, does at leaſt increaſe the image of the diameter of any object viewed through it 624 times. Therefore the object under conſideration is no longer than 1-624th part of 2 inches 1-10th, and 99-100 parts of another tenth, which by the preceeding method of calculation will be equal to 35-100dredth parts of 1-10th of an inch.

EXAMPLE III.

If we had only two revolutions, which in the firſt table anſwer to 293, this number expreſſes as we have before ſhewn, 2-10ths and 93-100th parts of another tenth, the ſame firſt magnifier being applied to the microſcope.—The diameter of ſuch an object would be no more than the 624th part of 2-10ths $\frac{93}{100}$dredth parts of another tenth, which is equal to $\frac{004}{10000}$thouſandths parts of one ſingle tenth part of an inch. What an amazing minuteneſs? and if we reflect on the far more ſurprizing minuteneſs of living animalcula, which are extended throughout the creation to a meaſure extremely ſmaller than that above-mentioned, and all diſcernable by a human eye, aſſiſted with ſuch magnifying powers, how can we forbear exclaiming with the Pſalmiſt, O Lord, how wonderful are all thy works! in wiſdom thou haſt made them all!

A

A NATURAL HISTORY Of a great VARIETY of AERIAL, TERRESTRIAL, and AQUATIC ANIMALS, &c. CONSIDERED AS MICROSCOPIC OBJECTS.

Of the circulation of the blood, and how to examine it by the microſcope.

THIS noble fluid, the blood, yields us the moſt ſublime ſpeculations imaginable, by the aſſiſtance of the microſcope. For by the help of it, human blood, and that of land animals, is found to conſiſt of round red globules, which float in a tranſparent fluid, each of which is compos'd of ſix ſmaller, and more tranſparent ones, and each of theſe (as Mr. Leeuwenhoek has ſhewn in his 128th epiſtle to the Royal Society) into ſix more minute and without colour. He hath alſo ſhewn us, how eaſily ſix ſoft flexible globules,

bules, which are compreſſible into any ſhape, and in continual motion, may, by ſtriking againſt each other, compoſe one large globule of a perfectly ſpherical figure, one of which, and five of the ſmaller ſort, as they appear in contact, the ſixth lying behind, is repreſented fig. 29. which, by their mutual attraction to, and preſſure againſt each other, readily unite to form a perfectly round body, as at fig. 30. Their attraction towards each other is ſo conſiderable, as to form a kind of fleſhy ſubſtance, when brought into contact; and their ſpecific [a] gravity more than the ſerum in which they float.

How theſe globules, and alſo the more minute ones of which they are compoſed, are occaſionally ſeparated, in order to paſs through extremely minute veſſels, which without ſuch a ſeparation they cannot poſſibly enter, and how they re-unite again in veſſels where they have more room, is eaſily comprehended by a due conſideration of the two foregoing figures.

The diameter of a common round globule of human blood, is equal to the 1940th part of an inch.

In order to view the blood with the microſcope, upon the tip of an hair pencil, take a ſmall drop of warm blood, immediately as it comes from the vein, and ſpread it as thin as poſſible upon the object-carrying glaſs of the microſcope, and apply it between the object plate and ſprings, to the firſt and ſecond magnifiers. It may alſo be extreamly well examined, if a little of it be taken up into a ſmall, but very thin capillary tube, which being held in the nippers of the apparatus, may be readily applied to the magnifier. If you dilute a drop of bood with warm water, and apply it either of theſe ways to the magnifier, ſome of the larger globules will be ſeparated from each other, and ſeveral of them will be divided into the ſmaller ones of which they are compoſed.

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[a] Phil. Tranſ. No. 361.

By either of theſe methods, the globules of the blood may be diſtinctly ſeen, and a little practice will diſcover any alteration that may happen in the colour, ſhape, or ſize of them; in its ſeveral changes between ſickneſs and health. Mixtures of medicinal, or poiſonous liquors, may be blended with it immediately as it comes from the vein, and a drop of this mixture, if applied as before directed to the microſcope, will diſcover what alterations can be produced on the contexture of the blood. The veſſel in which the blood is received, ſhould be put into a baſon of water, ſomewhat hotter than the blood [b], to prevent its coagulating before the mixture.

The circulation of the blood through its veſſels, is to be ſeen in ſuch ſmall creatures, whoſe tranſparency permits us to look within them, or in the thinneſt parts of larger ones; by which we are very well informed, the whole animal ſyſtem being eſtabliſhed on the ſame plan, the circulations carried on in veſſels of a like form, both in the meaneſt and nobleſt living creature, and accelerated or retarded by the ſame cauſes.

In theſe ſmall creatures we are not only able to ſee the general courſe of the blood, but can perfectly diſtinguiſh each globule, and the alteration they ſuffer in paſſing out of the larger into the more minute veſſels, many of them being ſo ſmall, that ſingle globules can ſcarce enter, till they are compreſſed into an oval form; and yet theſe very veſſels are large, when compared with the fineſt of all, in which the globules muſt be divided

and

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[b] The exact blood-heat of the water, may be obtained by a pocket thermometer, made with quickſilver, with which the reader may be ſupplied at my ſhop, at Tycho Brahe's Head in Fleet-Street, No. 60.

and ſubdivided into their ſmalleſt component parts, before they can find a paſſage.

Providence has been ſurpriſingly careful in the diſpoſition of the veins and arteries, for theſe laſt, which convey the blood to the extremities of the animal, continually leſſen their diameters in their progreſſion, and divide into ſmaller branches. At which diviſion, the globules ruſh againſt an angle, which as it were cauſes them to recoil upon thoſe immediately behind, before they can readily ſeparate into the two ſmaller branches C D, of the artery A B, fig. 31. in which the blood flows upwards from B to A, towards the extremity; and on the contrary in its return back from the extremities to the heart, their diameters increaſe, and thoſe ſmaller veſſels are continually uniting into larger, as in the foregoing, fig. 31. the branches C and D join their currents in the vein E F, till at laſt all their ſtreams fall into one, at every ſuch conjunction of two branches, as at E, and their ſtreams violently ruſh againſt each other, by which means unnatural coheſions are prevented.

The microſcope affords us an ample view of the veins and arteries, the latter of which is very diſtinguiſhable by a protruſion of the blood, at each contraction of the heart, then a ſtop, and then a new protruſion, continually ſucceeding each other, whilſt in the veins it rolls on with inexpreſſible rapidity.

The ingenious Mr. Leeuwenhoek hath told us, that with great admiration he ſaw in the utmoſt extremities of a very ſmall fiſh's tail, how the larger arteries were divided into the fineſt veſſels [c], and many of the ſmall veins, which returned from the ſaid extremities, met together in a larger vein; that there was ſuch an agitation of that blood, which flowed from the larger arteries, towards the evaneſcent ones, at the extremity of the tail, and returned afterwards through many minute veins into a larger one, as can hardly be conceived. In the larger arteries he ſaw a continual new protruſion of the blood's courſe, received from the heart; but in the ſmaller, the motion ſeemed equable without any ſuch repeated propulſion; and though no colour appeared in the minute veſſels, yet in the larger arteries and veins, that were near the extremity of the tail, the blood was plainly red.

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[c] Arc. Nat. tom. iv. p. 167.

The exact magnitude this fiſh appeared of to the naked eys, as delineated by him, is repreſented in fig. 32. Its tail magnified, as it appeared in the microſcope, at fig. 33. in which were ſeventeen little bones or griſtles, that give a ſtiffneſs to the tail, three of them are ſhewn by the letters A B C, on each ſide of which he ſaw a very open communication of the veins and arteries, the blood running through arteries, and returning back through veins, which were of the ſame ſize, and evidently a continuation of the ſame veſſel; this was diſtinctly ſeen in 34 different places, ſo that in the tail of this ſmall fiſh could plainly be ſeen 64 blood veſſels, 34 of them arteries, and as many veins, beſides the little ſpaces about D and E, which were not obſerved.

This will be better underſtood by a microſcopical repreſentation of part of one of theſe little griſtles F H G, fig. 34. on each ſide of which runs an artery I K and M N. The blood flowing rapidly from I and M, to K and N, their open communication with the veins K L, and N O, from whence it returned to L and O, ſo that both theſe were but one continued blood veſſel; for no veſſel can be properly called an artery beyond the pulſation; farther than which, and returning towards the heart, it may be called a vein; for veins, as by the preſent figure appears, are only arteries elongated; and as they generally divide into branches that eſcape the ſight, it is very difficult to determine where the arteries end, or where the veins begin. If in the tail of this ſmall fiſh, the whole bulk of which was no bigger than that of fig. 32. and conſequently under half an inch in length, 34 diſtinct circulations of the blood could be ſeen, how incredibly numerous muſt that of the circulation be in an human body? nor is it to be wondered at, when we ſee it iſſue forth at every prick of a pin or needle. In this conſideration he alſo adds, that he is fully convinced in a ſpace no bigger than his fore finger nail, a thouſand diſtinct circulations of the blood are performed.

Mr. Leeuwenhoek obſerved the motion of the blood in a ſmall veſſel, in the tail of a tadpole, ſomewhat wider than to admit a red globule thereof, as A and B, fig. 35. which veſſel is called an artery, through which the blood coming from the heart, in the direction A B, is impelled with great ſwiftneſs, and divided at B into two branches, B C and B E, which are again united at D, and continue ſo to F, where they are again divided into two other branches F G and F I running crooked till they are again united at H, where they formed a ſomewhat larger veſſel as H K, and became bigger at K, for which reaſon we muſt call the blood veſſels A B C, D F G, and A B E F I, arteries [d], becauſe they convey the blood to their greateſt diſtance from the heart at G and I, and the blood veſſels G H K, and I H K, veins, becauſe they return the blood to the heart again.

In another place he ſaw the blood running in an artery, large enough to admit about 20 red globules [e] at once; this was a great artery in proportion to that before-fore-mentioned, a ſmall part of which is delineated at L M, fig. 36. out of which proceeded a leſſer, as M O. The blood in the veſſel from L to M, had not ſo quick a motion as it had in others, becauſe the blood in the veſſel at R, did in a manner ſtagnate, inſomuch, that no ſeparated parts could be diſtinctly ſeen, it appearing there of one uniform red colour; yet in the veſſel M O, the circulation was as ſwift as in any other veſſel. That the blue ſpots, occaſioned by a fall or bruiſe, is not ſtagnated blood, which perſpires before it begins to corrupt through the ſkin with the ſweat, Mr. Leeuwenhoek was convinced of by the following obſervation. The blood at R being thus without the leaſt motion, it was by every pulſation of the heart impelled upward, from N to P, and the next moment recoiled back again, and this alternately with an undulatory motion; as is known if never ſo much violence be uſed in preſſing water, yet it cannot be preſſed cloſer than it was before; ſo the blood being now impelled forwards thro' the heart, cannot be compreſſed into a leſs ſpace; this being ſo, we muſt conclude, that the tunic of the blood veſſels between N and P, and alſo ſomewhat below N, is diſtended at every pulſation of the heart; and as ſoon as this uncommon diſtention is performed, ſo ſoon alſo does the tunic of the veſſel contract itſelf again; whereby the blood, that was thus puſhed forwards, is forced to run back again. After a ſhort ſpace of time he ſaw the blood begin to move from P to R, in ſuch a manner as to be puſhed back again, and that during his obſervation, the blood veſſel M O, was a little more extended; conſequently more blood ran through it than when he firſt began to look upon it; the blood in the veſſel N S, wherein was little or no motion before, now ran as ſwift as in any other veſſel; the veſſel P Q was ſo ſmall, that only one ſingle globule could paſs through it at once, wherein not the leaſt motion, at his firſt obſerving it, could be diſcovered, now began to flow; yet the particles of blood, which at firſt paſſed through it, were but few in number, and conſequently far aſunder; henceforward all the blood from P to R was put into motion, as well by being puſhed forward, as by recoiling back again, and that at every pulſation of the heart. Mr. Leeuwenhoek ſpent about two minutes in theſe obſervations; from whence it plainly appears, that the ſtagnant blood cannot only be made to move again by the motion of the heart, which we call the beating of the pulſe, but alſo that the coagulated red globules are again diſſolved, and aſſume their firſt figure; from which we may reaſonably conclude, that the coagulated blood in any animal, occaſioned by a blow or bruiſe, can in a few days be made to move again; it being taken for granted, that the heart of a man puſhes out the blood ſeventy-five times in one minute, which is 4500 in one hour, and 108000 times in the ſpace of a day and night; and finding that in 10 days time the coagulated blood ſeemed to vaniſh, and alſo conſidering that in this time the heart performs 1080000 pulſations, and that in each motion, into ſeveral veſſels together, there has been looſened and ſet a-going the quantity of a grain of ſand, how much more will be puſhed forward in the ſame time? Mr. Leeuwenhoek could ſee the blood received from the heart at each impulſe, in the veſſel above-mentioned. If we ſuppoſe that the quantity of a cubic inch of coagulated blood, occaſioned by a blow, is too much, and that ſeldom ſo much is coagulated at once, we may eaſily conceive, that ſuch coagulated blood, by means of ſo many protruſions as above-mentioned, may be looſened, and its motion again reſtored, if not in all, yet in moſt of the veſſels.

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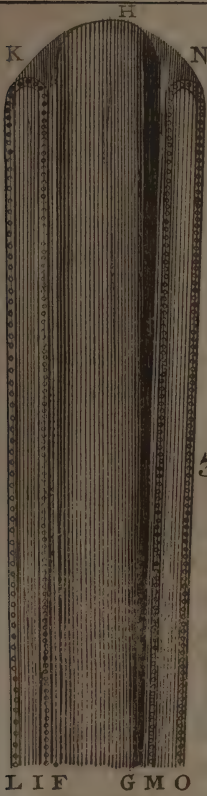
[d] Arc. Nat. Epiſt. 119.

[e] Phil. Tranſ. No. 260.

At another time Mr. Leeuwenhoek laid one of theſe tadpoles upon a piece of white paper, a little while before he came to look upon it. A ſmall part of the tail was wounded by the ſkin ſticking to the paper; ſo that out of an artery in the excoriated part, ſo large that about four red globules of the blood might paſs through it at once, there flowed ſome blood that remained without motion about the wounded part, yet that whereon his eye was fixed, not being half a hair's breadth from the excoriated artery, there proceeded a branch of a vein, wherein the circulation of the blood did ſtill remain, as if the artery had not been broken, fig. 37. T V, exhibits the artery wounded a little above V. V X ſhews the extravaſated blood. V W, the ſmall artery wherein the blood retain'd its full courſe, although it was ſo near the artery T V, out of which the blood flowed; which at firſt ſeemed very ſtrange, but obſerving that the blood-veſſel V W was united at W to a large blood-veſſel, that conveyed the blood to the heart, the blood out of V W was continued as ſwift as if it had been impelled from T to V, in ſuch a manner that Mr. Leeuwenhoek imagined, the vein at V had not been united with T, but had lain with its aperture at V, in the extravaſated blood; ſo that the extravaſated blood was only for a little ſucked up and conveyed through it. He then ſaw a vein wherein the motion of the blood ſeemed very uncommon, as at fig. 38. whereof a b repreſents an artery, whereby the blood is impelled with great velocity from a to b, then b c, whereby the blood is conveyed towards the heart, muſt be called a vein, cloſe by which lies another artery d c e, wherein the blood is conveyed from the heart from d to c; now if the vein b c be united with the artery d e, as is ſeen at c, and the blood be thus conveyed from c to e, b c ſhould be called a vein, and the blood coming to c, being there transfuſed into c e, is the arterial blood, becauſe it is conveyed thither from the heart, it being certain that d c e is an artery.

Amongſt others, Mr. Leeuwenhoek had a tadpole, wherein he could perceive no motion at all of the blood, how attentively ſoever he view'd it; at firſt there appear'd no reaſon for it, till upon examining this animal with his naked eye, he obſerved the fore part of his body was contracted, by which he imagin'd the heart was ſo oppreſſed, that it could not force out the blood, and receive it back again. Whilſt he was thus contemplating, the animal made a very ſtrong motion; beating its tail about, and bending its body, by which it got clear of the oppreſſion it was under; and on viewing it again, perceived the blood to have a ſlow motion, and impulſe in ſeveral veſſels, which increaſed till it at length came to its proper motion, yet not with ſuch velocity as it would have had, if the heart or body had not been oppreſſed. Mr Leeuwenhoek ſays, that the motion of the blood in theſe tadpoles, exceeds what he ever ſaw in any other animal. Fig. 39. exhibits a tadpole arrived to ſuch a bigneſs, as to uſe its hinder legs, and the fore legs were alſo diſcernable, but yet covered with the ſkin.

Mr. Leeuwenhoek obſerved the circulation of the blood in ſeveral butts, one of which, bating the tail, was but an inch in length; the greateſt motion of the blood obſervable through the fins, was on each ſide the various little ſingle bones placed therein, where the blood-veſſels were ſo large, that 25 of thoſe particles which conſtitute the blood of a red colour, could paſs in breadth, but diſappear'd as they drew nigh the extremity of the fins, ſmall veſſels being all along diſpers'd from



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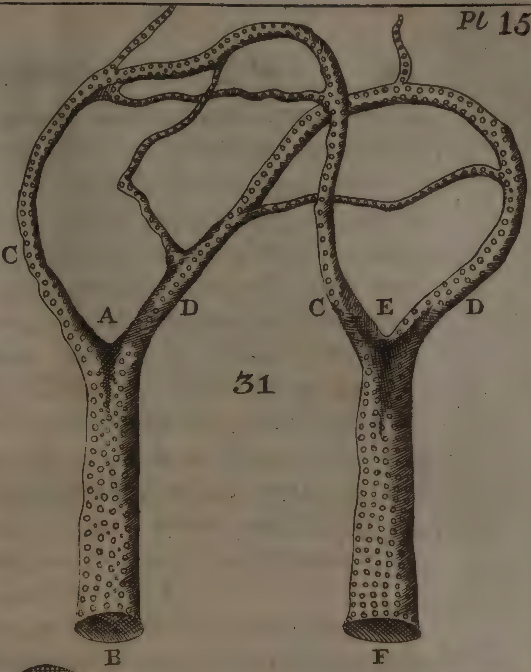

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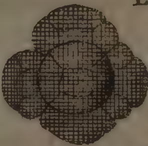

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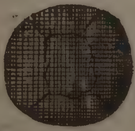

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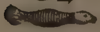

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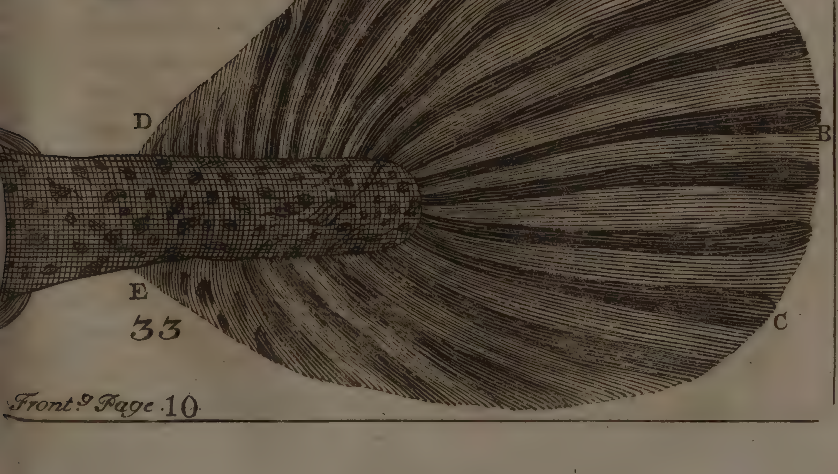

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from the arteries; on one ſide of a little bone, runs an artery, and on the other a vein, correſponding thereto; and finding it eaſy to extend the tail, he accordingly ſtretched it in breadth, equal to what the fiſh gives in ſwimming, that he might the better obſerve the motion of the blood in theſe extended veſſels, and found when the fiſh did not move, ſome of thoſe ſmall veſſels, which before received three particles in breaſt, being now ſtretched out with the tail-fin, which they run a-croſs, did not only admit no more than one particle, but likewiſe theſe particles did not move ſo faſt, as when the veſſels were not extended; and in ſome places were at ſuch a diſtance, that one or two more might lie in the intervals, but could not from all this determine, that the particles were perfectly oval [f].

But to trace the matter further, he took the blood running from a live ſalmon, [g] when cut into pieces, and put it into a glaſs tube, no larger than a ſmall quill, which in a ſhort time congealed; but when it became partly fluid again, he put it into a ſmaller glaſs tube, and having placed it before his eye in the microſcope, the particles being in motion, ſome of them appear'd of a flat oval figure, and others, which ſhewed themſelves ſideways to the eye, ſeem'd a little thick, and thoſe whoſe ſides did not directly face the eye, ſeem'd a little broader, without the leaſt appearance of any globular form. Mr. Leeuwenhoek alſo put ſome of the ſame blood upon a very clean glaſs, and where the particles lay thin, he perceived them oval; nay in ſeveral ovals he diſcovered globules, and in ſome few ſix globules.

Fig. 40. A B C D repreſent the oval particles of the blood of a ſalmon, that weighed 30 pounds; A B, the particles that appear'd flat and broad, but did not directly face the eye; thoſe about c were ſtreight before the eye, and for the moſt part a little clear ſort of light in the middle, larger in ſome than others.

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[f] Arc. Nat. Epiſt. 128.

[g] Phil. Tranſ. 263.

Mr. Leeuwenhoek, likewiſe, placed ſome of the blood of a very ſmall butt before the microſcope, which was not mixed with any liquor, only the particles lay in their ſerum, and are repreſented by fig. 41.

Thoſe particles of the blood, which are diſtinguiſhed by ſhining ſpots in the middle, are delineated fig. 42, Mr. Leeuwenhoek proſocuted this enquiry yet farther, with a greater magnifier than he had hitherto uſed, and ſo he plainly made out the oval particles; now the greater the magnifying power of the glaſs, the ſwifter does the circulation of the blood appear; and having retarded this motion, he employed two or three ſeconds of time, in obſerving the little veins, and found, that in ſeveral ſmall veſſels, the oval particles were ſo broke, that he could neither ſee them, nor thoſe, of which ſix conſtituted a particle of blood, but only a ſimple fluid of a faint colour, running along the veſſels; but in a great artery at the tail, the blood mov'd ſo ſlowly, that he could eaſily diſcern the particles were oval; and not only ſo, but he likewiſe perceived more clearly than before, the globules that conſtituted the oval parts, if not always, yet at leaſt for the moſt part, as repreſented in fig. 43.

How veinous blood may become arterious without being firſt in the heart, appears by the following experiment. Suppoſe A B, in fig. 44, to be a vein, in which the blood view'd through the microſcope, paſſes with great celerity from B to A; from this vein proceeds two ſmall branches, C and D, which unite between E and F. Again ſuppoſe H I to be an artery, in which the blood moves upwards with equal ſwiftneſs from H to I, out of H I ariſes a veinous ſpring, delineated in K F L, ; the blood moving from K to F, joins the other at F ; and by this means, part of the blood coming from the artery, is thrown into the vein, as paſſing from F to G, and to the beſt of Mr. Leeuwenhoek's obſervation, a quantity of blood, juſt equal to that carried from K F to G, moves from C E to F, and directs its courſe upwards from F to L, ſo that whatever quantity of arterious blood paſſes through K F and F G, an equal quantity of veinous blood returns through C E and F L. Though the agreeable motion of the blood was formerly apparent, yet this experiment afforded him a very clear perception of the above-mention'd variety ; and beſides, this union of the blood-veſſels was not formerly diſcover'd.

Mr. Leeuwenhoek, in his 112th epiſt. has given us an accurate delineation of the blood-veſſels in part of the tail of an eel, whoſe whole length did not exceed that of the length of his little finger. The figure, as by him delineated, is repreſented in fig. 45. whereof A C E repreſents the veins, and B D F arteries.

The letter D repreſents an artery, from which a branch G proceeds, that is divided about H, into two leſſer branches, one of them repreſented by the letters H I K ; ſo much of this ſmall veſſel as reaches to I, is called an artery, becauſe the blood may to that place be propelled in its progreſſion from the heart. The other part I K of the ſame branch may be called a vein, becauſe by it the blood is convey'd back again to the heart. In the other part of the ſame branch H L M, the blood is drove forwards till it arrives at M, where it is diſcharged into the vein E, which in this figure is the firſt place that can take the name of a vein.

Here alſo it may be obſerved, that as the arteries are extended in length, they gradually leſſen. And on the contrary, the veins increaſe in their diameters as they approach the heart.

Furthermore, from this ſame artery D, another veſſel may be ſeen branching out from N, from whence the blood flows to O, and there diſcharges itſelf into the vein E.

Raiſe your eye a little higher to P, where another ſmall artery advances from the great one D, towards Q, where it cloſes again with the vein E.

Alſo obſerve that about the letter R, another ſmall veſſel leads from the ſame artery towards S, at which place the blood that flows both from the artery D and B, is joined, and from thence pour'd into the vein C.

Somewhat higher, about T, advances a little blood-veſſel, which is divided into two branches at V, ſo that from thence two diſtinct veſſels may be ſeen to diſcharge themſelves into the vein E, at X and h.

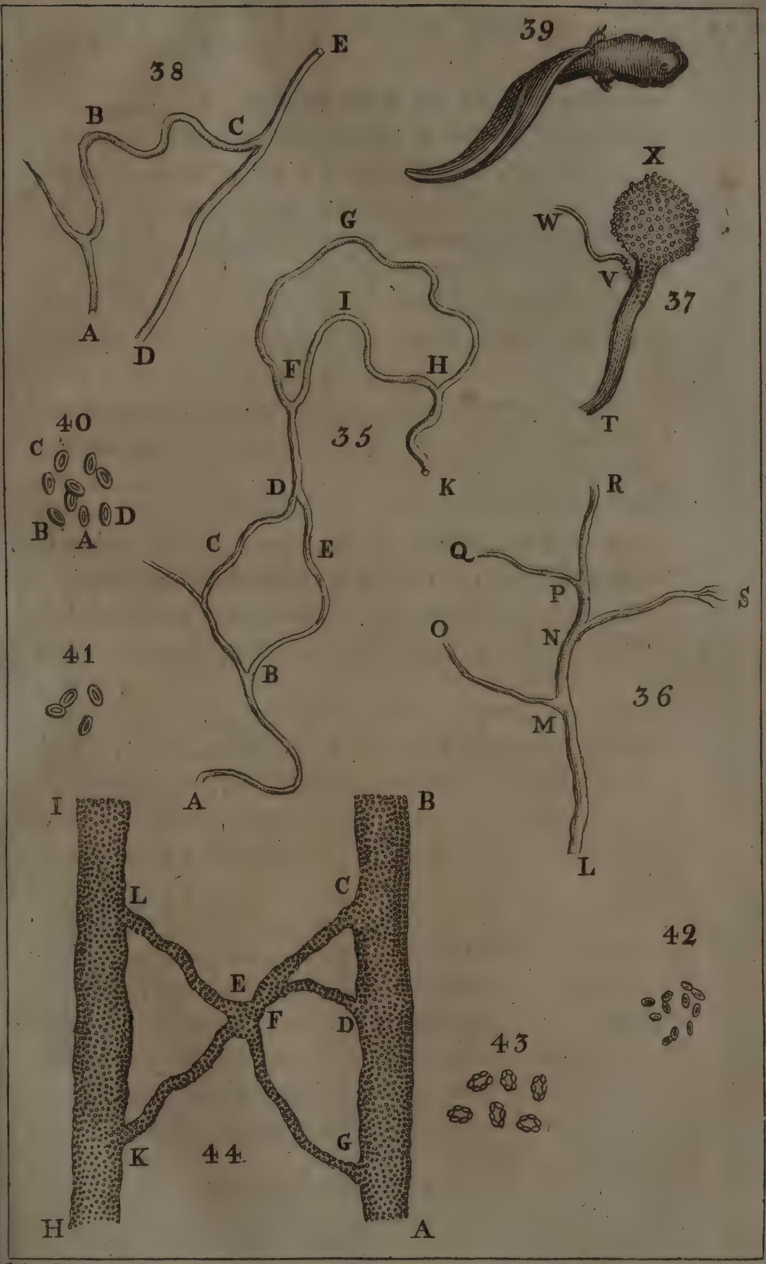
About the letter Y proceeds from the ſame artery D, another ſmall veſſel, which at Z branches out in two more minute veſſels; the blood flowing through them towards a and b, where it is diſcharged into the vein C.

Not far from Y, about c, proceeds a ſmall branch from the artery D, through which the blood alſo returns into the vein C, with which it joins at d.

From the ſame artery D riſes a minute branch e, f, which is ſeparated into two leſſer branches at f, ſending back the blood to the vein E, at g and h.

If the ſame artery be examined a little higher, another branch I k l, will be ſeen iſſuing from I, which is alſo divided at l into two others, that likewiſe diſcharge themſelves into the vein E, at m and n, near I; at o, are alſo two

Pl. 16.



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two other branches, which vent their ſtreams at p and q, into the vein C.

Moreover from the ſame artery D, about r, proceeds forward a ſmall one r ſ, which is divided into finer branches, one of which r ſ t, joins the vein C, the other ſ, u, w, x, joins the vein E at x.

The moſt evaneſcent artery, flowing from the large one D, which is repreſented by the letters r y z, unites with the vein E at A; the ſame minute artery, near the letter u, is again divided into two branches, the part u b is diſcharged into the vein C, at t.

An eel of this ſize may be conveniently placed before the magnifiers in the microſcope, either in the fiſh pan, or in a ſmall glaſs tube filled with water, and put between the object-plate and ſprings, after wiping off its ſlime, which would obſcure the glaſs, ſtop both its ends to prevent the water from running out; the tail may then be viewed, and the circulation will appear in an agreeable and pleaſant manner, as in the foregoing figure is deſcribed.

The tails of any ſort of ſmall fiſh, may be alſo readily applied to the magnifiers in the ſame manner. Under the ſpring of the fiſh-pan, or tied on a flat glaſs, flounders, eels, and gudgeons live a long time out of water, and are to be had at almoſt any time in London alive.

Alſo the tail[h] of a water newt, or a lizard, if applied to the microſcope in a glaſs tube, repreſents an agreeable proſpect of the circulation, through variety of ſmall veſſels, particularly in an exceeding ſmall one of the water-kind, which may ſometimes be procured ſhorter than an inch, and ſo tranſparent, that the blood may be ſeen running in all directions, not only through the tail, but particularly in every ſingle toe, and through its fins or pointed branches. The blood may be ſeen running through an artery towards the extremity, and returning through a vein, with which its communication is very apparent, and ſurpriſingly delightful.

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[h] Phil. Tranſ. No. 288.

Mr. Leeuwenhoek informs us, that he has obſerved the circulation of the blood, in the fartheſt joints of little crabs[i] hinder legs, with greater rapidity than in any other creature, and that their red globules were twenty-five times fewer than in any other land or water animal he had before examined.

Exceeding ſmall crabs may be found under brickbats and ſtones, on the ſhores of the river Thames, when the tide is out.

The circulation of the blood may be ſeen in the legs and tails of ſhrimps, if view'd in water, wherein you have mixed a little ſalt; but in theſe the blood is not red.

I have frequently ſeen a fluid flowing through the filmy wings of graſshoppers, of a greeniſh colour.

The motion of the blood is alſo to be ſeen in the tranſparent legs and feet of ſmall ſpiders, and in the legs of very ſmall buggs, and an extraordinary vibration of the veſſels not diſcernable in other creatures.

You may often obſerve in viewing ſeveral of thoſe objects, the globules cannot paſs through the ſmaller veſſels, otherwiſe than ſingle, and then ſqueezed into an oval form

If a little frog's ſpawn, in the ſpring time, be kept a few days in ſome of the ditch-water, in which it is found, you'll have a great number of exceeding ſmall tadpoles, which at their firſt beginning to ſwim, are nearly tranſparent; place them before the microſcope in a ſmall tube, with a little water, or in a cylindrical glaſs, and you

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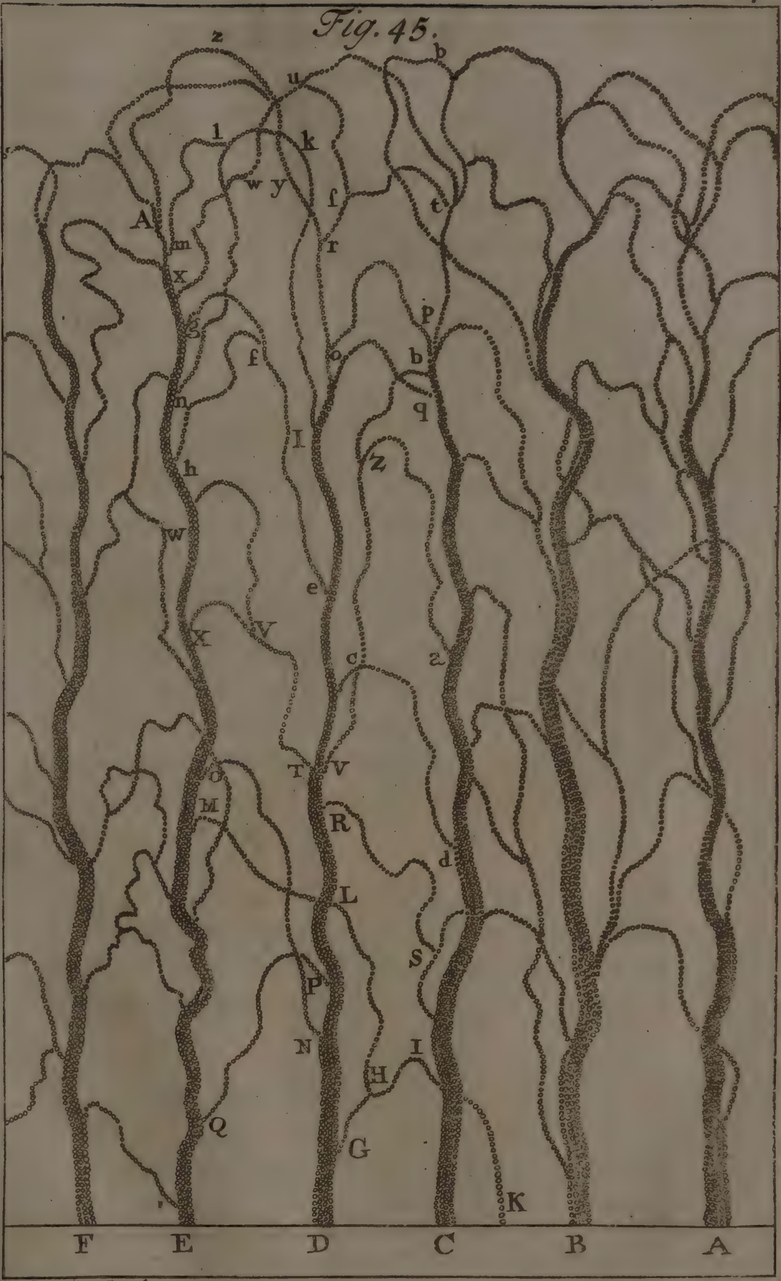
[i] Arc. Nat. Tom. iv. Ep. 84, and 86.

Fig. 45.



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Bowles sc.

you may behold the circulation of the blood in every part of the ſubject, and in a more particular manner in the tail, near [k] fifty veſſels preſenting themſelves at once to view; and alſo the pulſation of the heart; but they grow ſo opake in a day or two, that the circulation can then be only ſeen in the fins, and at the joining on of the head, and in the tail.

The circulation of the blood affords an entertaining ſight in the thin membrane between the toes of the hind foot of frogs, if well expanded; and placed before the magnifier, the arteries and veins will be diſtinctly ſeen.

The blood may be retained in the lungs of frogs and lizards, as follows; on making an inciſion into the bodies of theſe animals, their lungs will ſtart out, and be diſtended with inſpired air; on theſe, as quick as you can, paſs a waxed thread, and tie it firmly towards the upper part of the lobe, as near the heart as poſſible; when the lungs are dried, after being thus diſtended, they may be placed in parts, between the talcs of an ivory ſlider, and by this means you may always keep by you objects of the lungs of thoſe animals, only remember to place their external ſmooth ſurface towards the magnifier. Theſe ſeveral parts of the lungs are very entertaining objects in the microſcope.

But the circulation of the blood is no where ſeen with ſo much ſatisfaction as in the meſentery of a frog. For which I have contrived an eaſy method to hold the animal during the operation, as will be ſeen in what follows.

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[k] Arc. Nat. Epiſt. 112.

The deſcription of a new apparatus for confining frogs, mice, bats, or any other creatures of the like ſize, particularly adapted to the variable and improved ſolar microſcopes.

THIS apparatus conſiſts of a ſquare frame of braſs A, B, C, D, fig. 46. which may be taken to pieces at pleaſure. It is held together at the corners, by the four pillars F, F, F, F, which alſo ſupport the frame. At the lower end of the two pillars which ſupport the corners C and D of the frame, is fixed a ſteel bar G H, having one of its ends made faſt to one of the pillars at G, and the other end ſcrewed to the oppoſite pillar by the nut H: on this ſquare bar is fitted a ſliding ſocket I K, to which are fixed the ſtems for placing it to the microſcope.

When a frog is to be diſſected, tie a ſtring to each of its four legs; firſt having ſtrained ſtrings thro' ſome of the principal holes of the frame, croſſing each other, as in the figure is repreſented by the ſmall letters a b, c d, e f, g h, i k, l m, which form a kind of lattice, or couch, whereon to extend the frog. Then firſt put the two ſtrings which are tied about his arms, through two holes, the neareſt to the corners A, C, and there fix them with two pegs made of fur, as at n and o, in the figure. The reaſon why I direct his two fore legs or arms to be faſtened firſt is, becauſe you may with eaſe hold his hind legs in your hand, till the fore legs are pegged down faſt; whereas if you attempt to fix the hind legs firſt, the creature will give ſuch ſprings and ſtarts, as will not only tire himſelf, and thereby prevent him from being able to go through the operation, but even make it almoſt impoſſible for you to fix him to your mind. Then fix his hind legs as before directed by the pegs p, q. If now you find him not quite faſt, you may make him ſo, by pulling out one of the pegs at a time, and ſtraining the ſtring a little tighter, after which replace the peg. The ends of the ſtrings which confine his arms and legs, are repreſented in the figure by the letters r, ſ, t, v, and the frog lying upon his back.

The object being thus extended, and faſtened on the frame, as above directed, open the ſkin of the belly, from near the anus to the throat, in the direction of the dotted line I K, by firſt juſt entering the point of a very ſharp penknife at I, through the firſt ſkin only, taking care not to touch the ſecond ſkin, and let the inciſion be no longer than the little ſtreight ſtroke I w, in which thruſt the probe or director, fig. 47. almoſt up to his throat, with the curf x y upwards, in which curf you may run the point of a pair of ſciſſars, without being in any danger of cutting any other part of the ſubject, and thereby open the upper ſkin from I to K, then turn the director ſideways from K to L, and from I to M, and give it a little ſnip in that direction, both at the top and bottom. Stick a fiſh-hook, with the barbs filed off, into each corner of the ſkin, firſt having put the ſtrings N O, to which the hooks are tied, through any two of the holes in the frame, as at P and Q. Then by gently pulling the ſtrings N O, the ſkin will readily ſtretch out into the direction of a ſquare flap, as repreſented in the figure by the letters L M R S, and the three dotted lines which ſurround them.

If now you fix the frame to the microſcope, you may place any part of this flap before the magnifier, either by ſlipping the ſquare ſteel bar G H backwards and forwards in its ſliding ſocket I K, or elſe by pulling the ſaid ſocket farther from, or puſhing it nearer to, the pillar of the microſcope, by which means, you may with the greateſt eaſe imaginable, examine all the blood-veſſels in this tranſparent flap or piece of ſkin, by ſitting at a table before a window, and directing the illuminating glaſs, ſo as to fling the rays of light immediately under this part of the ſkin.

If the ſun ſhines, and you have the ſolar apparatus before deſcribed, ſcrewed ready in the window ſhutter, apply the microſcope and frog to the ſolar part as before ſhewn, and after having directed the ſun's rays through the tube, upon any part of the ſkinny flap L R S M, and placed the ſcreen at about four or five foot from the machine, ſo as to receive the ſun's rays, and adjuſted the object to the focus of the magnifier, and diſtance of the ſcreen, you will have repreſented on the ſcreen, a moſt beautiful picture of the veins and arteries in the ſkin, with the blood circulating through them; in the arteries you may plainly perceive the blood ſtopping, and as it were receding a little at each dilatation of the heart, and then immediately ruſhing forwards again at each contraction; whilſt in the veins it rolls on in a continual current, with inexpreſſible rapidity; and when the arteries are very much magnified, if you remove the ſcreen to a conſiderable diſtance, the alternate expanſion and contraction of their ſides are very viſible.

When you have conſidered this as long as you think needful, open the abdomen, and extend the muſcles before the microſcope, by means of the two fiſh-hooks, as before in the extenſion of the ſkin, and you will with pleaſure view their ſtructure, which conſiſts of numbers of tranſparent ſtrings or fibres, lying parallel to one another, and joined together by a common membrane.

Theſe ſtrings or fibres appear through their whole length, to be made up of minute roundiſh veſicles; and the blood veſſels which intermix with them, afford an agreeable proſpect.

The next experiment is gently to draw out a part of the frog's gut, in order to apply the meſentery to the microſcope, which is a moſt beautiful and ſurpriſing phenomena, when viewed through the microſcope, as ſtanding upon a table: but when applied to the ſolar apparatus before deſcribed, you may view it in ſo diſtinct and fine a manner, that no words can deſcribe the wonderful ſcene which will then be preſented to your ſight. The blood flowing through numberleſs veſſels at one and the ſame inſtant, in ſome one way, in others the quite contrary; ſeveral of the veſſels may be magnified an inch in diameter, and the blood globules rolling thro' them, will appear near as large as pepper-corns, and at the ſame time in the minuteſt veſſels only ſingle globules can find a paſſage, and that not without putting on the form of oblong ſpheriods; here alſo in the moſt inexpreſſible manner, will be ſeen the pulſation and acceleration of the blood in the arteries, as before deſcribed.

As the animal grows languid, and near expiring, the blood in the arteries will be ſeen to ſtop ſuddenly, and as it were ſeem to coagulate, and then run backwards for ſome time; after which it will again recover its natural courſe, with a great deal of rapidity.

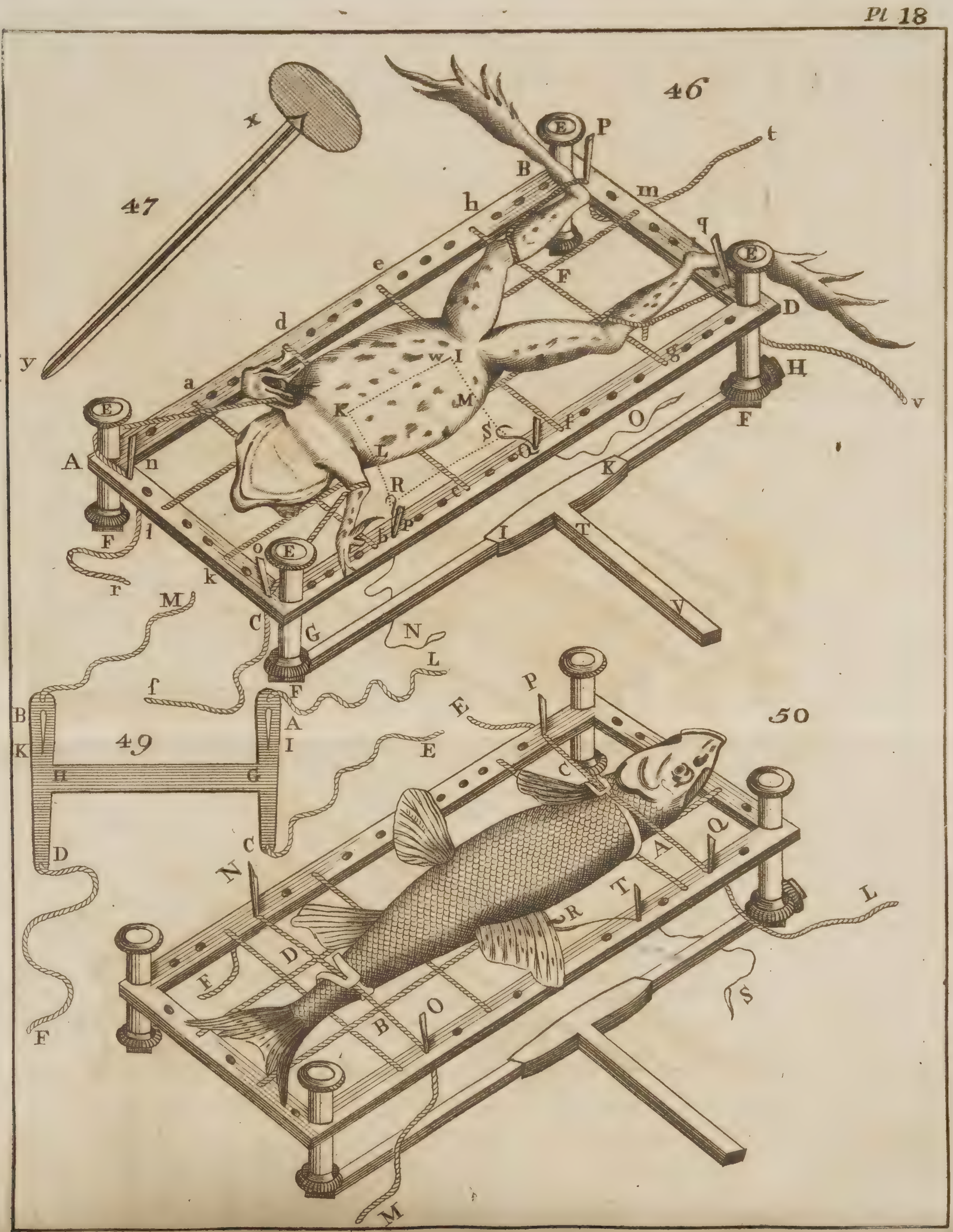
A due conſideration of theſe appearances, may poſſibly account for the intermiſſions, ſtarts, and irregularities in the pulſe of perſons near the point of death.

Fig. 48. M, L, R, S, repreſents a microſcopic picture of a part of the frog's gut, and meſentery extended, by means of the fiſh hooks R, S, M, the ends of their ſtrings being pegged to the ſquare frame, one of which is ſeen at p. B, I, K, C, is a part of the body of the frog. And I, K, that part where the belly was opened. D, E, part of the ſquare braſs frame. The ſhaded part within the gut, marked M, L, R, S, is called the meſentery, in which is plainly ſeen the blood-veſſels. Thoſe veſſels, which are a little darker than the reſt, are called arteries. In every one of which I plainly ſaw a pulſe, and the blood flowing from A to R. The others are veins, through which the blood flowed in a conſtant ſtream, in the direction V, N.

As there are many ſmall fiſh, whoſe fins are more tranſparent than their tails; I thought it might be acceptable in this place, to give a cut of the manner how they may be faſtened upon the ſame frame the frog was, which take as follows.

Firſt cut a piece of leather in the ſhape of fig. 49. and tie a ſtring to each corner of it, as at A, B, C, D, and obſerve, that the part G H of the leather be no longer than from the fiſh's neck to the part where the tail begins to grow ſmall, and cut a ſlit from A to I, and from B to K, then put the ſtring C E through the ſlit A I, and the ſtring D F through the ſlit B K, and put the fiſh in head foremoſt; after which draw the ſtrings cloſe, and apply it to the frame, fig. 50. fixing down the ſtring D F to the frame by the peg N, and the ſtring B M by the peg O. The ſtring C E may be made faſt with the peg P, and the ſtring A L with the peg Q, in which poſition the fiſh cannot poſſibly get away, but on the contrary will lie exceeding quiet: then may you ſtick a fiſh-hook to the thick part of its fin at R, and ſtretch it out by drawing

Pl 18



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drawing the ſtring R S gently, and then making it faſt by the peg T.

After which place the frame to the microſcope, as above directed; and you will have a beautiful proſpect of the circulation, if viewed through the microſcope upon a table; but much more ſo if you apply it to the ſolar apparatus.

I hope by this time the reader will be enabled to fix any other ſubject of the like ſize to the apparatus, in order for diſſection, and alſo be ready at applying them to the microſcope, either to be looked at by the eye through the magnifiers, or caſt upon a ſcreen when applied to the ſolar apparatus. The reader will alſo perceive that none of the modern microſcopes are ſo capable of having all ſorts of ſubjects applied to them, as theſe are in an apparatus, ſo eaſy in its uſe, as to give gentlemen as little trouble as poſſible in the application of all ſorts of objects.

Of Bones.

THEIR ſuperficial part is found to conſiſt of a vaſt many ſmall veſſels, and ſome few of a larger ſize; which laſt, when they came to the ſurface of the bone, appeared to Mr. Leeuwenhoek either with a membrane, or bony ſubſtance, perfectly tranſparent: he once diſcovered four or five veſſels in a ſmall piece of a ſhin bone of a ſufficient ſize for a ſingle filament of ſilk to paſs through them, and one of them ſeemed to him to have a valve [1] ſo diſpoſed as to admit nothing into it, but only to let out what was therein contained.

The ſpongy or cellular ſubſtance on the inſide of the bone conſiſts of long particles cloſely united, that are made

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[1] Phil. Tranſ. No. 366.

made up of a vaſt many ſmall veſſels, ſome running lengthways, others tending towards the ſides of the bony particles, ſome lying parallel, and others perpendicular to the length of the bone; theſe laſt have veſſels proceeding from their extremities; and others that compoſe the cortex, or ſuperficial part of the bone, proceed from their ſides; thoſe long particles, which lie parallel to the length of the bone, emit veſſels from their ſides, that iſſue out through the ſide of the bone. It is impoſſible to conceive what a prodigious number of ſmall veſſels compoſe the cortical part of the bone, which on the ſpongy part in ſome places is no thicker than a human hair; though, in others, three or four times that thickneſs.

The perioſteum is united to the cortex of the bone, not only to the outſide of the cortex, but even by entering into its very ſubſtance in ſeveral places, and is joined thereto by the veſſels which proceed from the bone.

Fig. 51. repreſents a ſmall part of the bone with the perioſteum adhering to it; A B C D E F ſhews the bony part, B G H I E the perioſteum, in which all the ſmall veſſels are repreſented by dots. In other places where the thickneſs was twice as much, not only thoſe veſſels that had been tranſverſly cut, and conſequently repreſented by many points; but alſo many other veſſels running lengthways, as in fig. 52. L O P Q N M and that part repreſented by B G H I E, fig. 51. are not entirely membraneous, but really bony. K L M N A repreſent the bony part, in which though no pores or veſſels are here repreſented, yet it is full of openings. Fig. 53. R S W X T V repreſents a part of another bone, S W X T the perioſteum, which in this place was no thicker than a large hair of a man's beard; but in another part of the ſame, and at a ſmall diſtance, it was four times that thickneſs. In another piece of bone ſo placed before the microſcope as to ſhew only the perioſteum and muſcular fibres, which were cut tranſverſly, and appeared to be ſurrounded by fibrils of the perioſteum, as in fig. 54. where Y Z A B is the perioſteum, and Z C D A are the fleſhy fibres cut tranſverſly; this was part of a rib taken from a fat ox.

It appears therefore from Mr. Leeuwenhoek's obſervation on bones of all kinds, that they do conſiſt of exceeding ſmall veſſels, ariſing from the inner hollow or ſpongy part of the bone, and paſſing through the ſuperficial or cortical ſubſtance, enter the perioſteum; and from thence are continued farther into the body, even to the remote parts thereof. Hence it is, that in a healthful body there is a conſtant ſupply of an oily ſubſtance conveyed into the bones; which again is conſtantly carried out from the bones by means of theſe veſſels into all parts of the body, even to the extremity of the fingers. He examined a very ſmall piece of the ſolid part of the ſhin-bone of an ox, and found it to conſiſt of four ſorts of tubes, perforated lengthways. The firſt ſort ſo ſmall and ſo cloſely united, as ſcarce to be diſcernable in a tranſverſe ſection of it. The ſecond ſort of tubes (ſome of which are four, ſome ſix times larger than the firſt) are alſo difficult to be diſcover'd; becauſe in cutting or ſhaving the bone, although the knife was ſharp, it deſtroyed and broke many of the tubular parts, which ſhut up their apertures. The third ſort greatly exceed thoſe of the ſecond, but were alſo difficult to be diſcerned, becauſe the knife tore ſome of them in cutting; yet notwithſtanding he was perſuaded, that bones are compoſed out of ſucceſſive additions of rings of tubes, in the ſame manner as wood is. The fourth ſort are much larger than theſe, and fewer, as will appear in fig. 62. whereof M repreſents a very ſmall piece of a ſhin-bone, which when viewed by the naked eye, appeared no bigger than the ſpot, fig. M.

A B C D is the ſame piece of bone magnified, E F G is the point of a very ſmall needle, upon which this little piece of bone[m] was ſtuck for examination before the microſcope, he was not able to repreſent the firſt ſort of theſe little tubes in the picture, becauſe their ſurface was ſo mangled in cutting; but the ſecond ſort is repreſented by the letters H H H, the third ſort by the letters I I I, which are ſeldom circular, but o different ſhapes, like the great veſſels in wood. The fourth ſort are a great deal larger, as ſhewn by the letters K K. The curved lines L and M are little clefts or cracks made by the knife in cutting.

To examine the bones, ſhave off with a very ſharp razor thin pieces of them croſsways, lengthways, and obliquely, and that from the inſide, outſide, and middle of the bone: then apply to the microſcope ſome of theſe ſhavings dry, and others moiſtened with warm water, by which means you may view the veſicles in all directions. Or put the bones in a clear fire till they are red hot; then carefully taking them out, you will find the bony cells perfect and entire, and being quite empty, may be view'd with great eaſe and pleaſure.

They may be applied to the microſcope either upon hollow glaſs, or ſtuck upon the point of a very ſmall needle, which needle may be held between the nippers of the apparatus, and thereby examined with eaſe, and little bits thereof may be preſerved between the talcs in an ivory ſlider.

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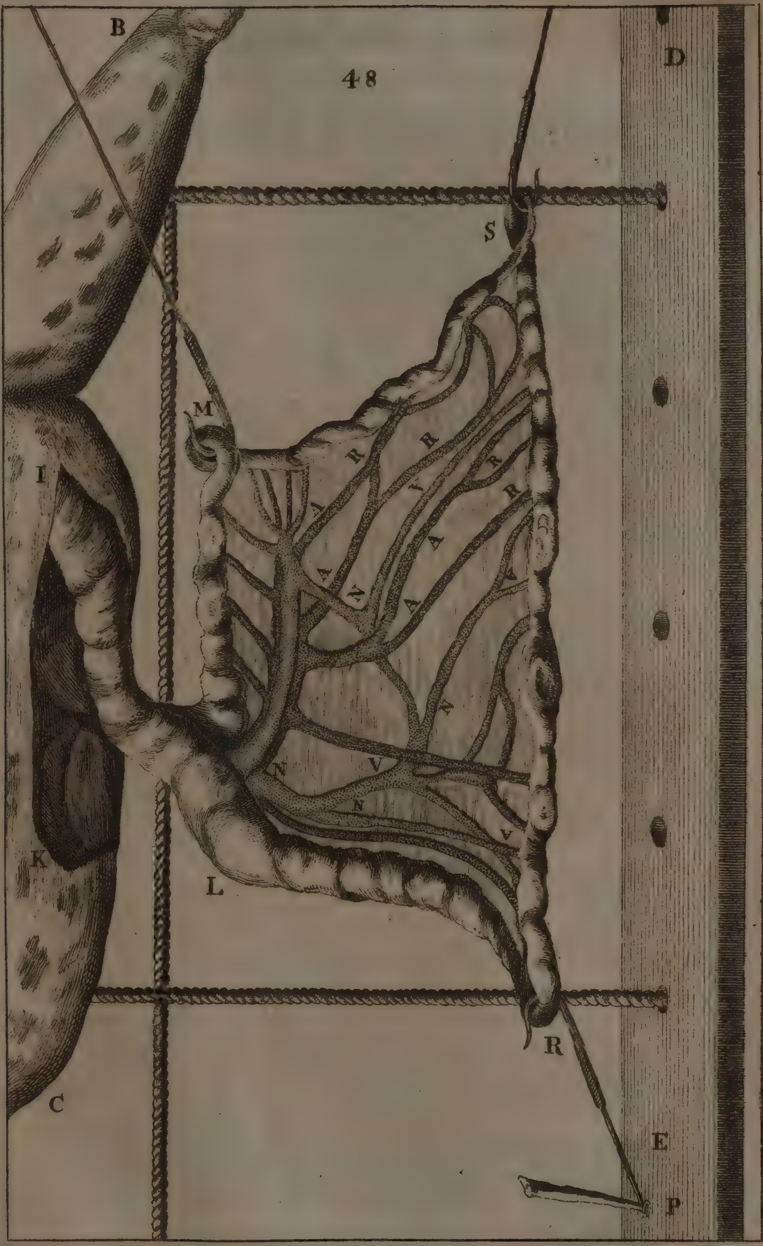
[m] Arc. Nat. Tom i. p. 200.



J. Wigley. Sc.

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Of the muſcular or fleſhy fibres of animals.

MR. Leeuwenhoek hath diſcovered each muſcular fibre to be made up of ſmaller fibrils, which, notwithſtanding their ſmallneſs, he plainly diſcern'd to be vaſcular, for on cutting a-croſs their length, the light might be ſeen through their apertures; but if he cut them ever ſo little obliquely, could ſee no light. He alſo obſerved the ſtructure of the fibres in the fleſh of an ox, and of a whale, but plainer in that of a whale; the fibres of the other being more compact and cloſe; and found alſo that the fibres of a mouſe were of the ſame ſize as[n] thoſe of an ox; from whence he concludes, the different ſize of animals is entirely owing to the number and length of their fibres. Theſe fleſhy fibres appear throughout their whole length, to be encompaſſed as it were with ſpiral circumvolutions as is exactly repreſented in fig. 69.

Which diſpoſition ſeems to be wonderfully contrived for readineſs in the diſtenſion and contraction of the fibres. Two of thoſe fleſhy fibres are repreſented by G H, and I K, fig. 68.

To view the muſcular fibres with the microſcope, cut off a piece of dried fleſh or fiſh, as thin as poſſible, and lay it upon a glaſs ſlip, and moiſten it with warm water, which drying ſoon away, will leave the veſſels open and diſtinguiſhable. As the learned differ in their opinions with reſpect to the figure and ſtructure of theſe little veſicles, I ſhall leave it to the curious for farther examination.

Mr. Leeuwenhoek informs us, that the fleſhy fibres in inſects are no leſs viſible than thoſe of larger creatures,

[n] Arc. Nat. Tom. iii. p. 108.

tures, which he found by cutting off the legs of flies, gnats, ants, &c. in all which he could plainly diſtinguiſh the circular wrinkles or circumvolutions encompaſſing the fibres, as in fig. 69.

Upon cutting the fleſhy fibres of a whale, lengthwiſe, and a-croſs,[o] he plainly diſcovered each particle, or fleſhy fibre, to be enveloped in a fine thin membrane. It appear'd in the microſcope, as repreſented fig. 55. in which the parts lay ſo cloſe together, that their encompaſſing membranes, repreſented by the black lines, were but juſt diſcernable; ſome however appear'd larger than others, and theſe,[p] if attentively view'd, ſeem'd to be divided into a great many others, ſome alſo cut tranſverſly, and crowded ſo cloſe together, that their figure, as well as ſize, was very different. Fig. 56. repreſents a thin ſlice of the fleſh of a whale, which after having been made thoroughly wet, and applied to the microſcope, appear'd as in the figure. Upon letting the moiſture evaporate from theſe ſlices, the particles became much ſmaller, and the membranes, with which each was encompaſſed, were very viſible. Fig. 57. repreſents a piece of the ſame fleſh, wherein the particles ſeem'd to touch, but on their being dried, ſhrunk up, from the ſurrounding membranes, whereas the membranes themſelves could not ſhrink, becauſe they were all join'd together. All along theſe fleſhy fibres[q] run membranes about the thickneſs of an hair, and diſtance of a grain of ſand; from theſe larger membranes, other parts were ſpread, dividing each fibre into a great many fibrils; from whence we may ſay, that each fleſhy fibre, no bigger than an hair, is a ſmall muſcle encompaſſed with its peculiar coat or membrane. Fig. 58. repreſents a ſmall piece of theſe fibres greatly magnified.

[o] Epiſt. Phyſ. p. 3. [p] Ibid. p. 4. [q] Phil. Tranſ. No. 39.

magnified. On moiſtening again the fibres repreſented by the two laſt figures (that were dried and ſhrivell'd up) they became ſo diſtended, as to fill up the ſpaces between the membranes, and re-aſſume the ſhape they had before they were dried. Among ſeveral little pieces of fleſh, moiſten'd as above, and placed before the microſcope, there was one, whoſe particles were not ſeparated upon drying; ſuppos'd to be owing to the ſplitting and tearing aſunder of a large membrane, which run through its middle, as repreſented in fig. 59. by Q R S T V W, where between S T and V the dried particles remain unſeparated, S W ſhews the thick membrane that divided this piece about the thickneſs of an hair, that ſent out a branch at T, and at W was ſplit into two. Fig. 60. repreſents a very ſmall piece, conſiſting only of five fibres cut lengthwiſe, as they appear'd through the microſcope; between C and F may be ſeen the little membranes which encompaſs the fibrils, but are here torn aſunder. Fig. 61. exhibits four ſmall fibrils of a piece of fleſh of another whale, by which it plainly appears, that the diameters of theſe fibres are as ſmall again as thoſe in the foregoing figure, therefore they muſt be four times as big as theſe; as each fleſhy fibre is compoſed of a great many ſmaller fibrils, we may imagine each of theſe incloſed ones, to conſiſt alſo of others of the like nature.

Mr. Leeuwenhoek, on viewing ſeveral ſmall fibres of ox fleſh, obſerved each of its contained fibrils to be encompaſſed with a thin membrane; but could not ſhew theſe membranes ſo diſtinctly to others in this fleſh, as in that of a whale; becauſe the parts of the firſt are of a texture much more compact and cloſe, than thoſe of the latter; for which reaſon they do not ſhrink ſo much in drying. And is alſo of opinion, that what he has ſaid of the membranes encompaſſing the fibres and fibrils of whale-fleſh, will alſo hold true in other kinds of fleſh, even down to that of a rat or mouſe.

Mr. Muys confirms the foregoing obſervations on the fleſhy fibres of the muſcles, being compoſed of ſmaller fibrils, and computes that 500 or 600 of them may be reckoned in one fleſhy fibre, whoſe diameter is the 24th part of an inch,[1] and that each of theſe fibrils are alſo made up of more than 300 tranſparent tubuli, but ſo ſlender as not to admit a 24th part of a ſingle globule of blood. He has ſhewn, that though the fleſhy fibres of the muſcles are joined to the tendons, and tendinous membrane of a muſcle; yet thoſe tendinous fibres are not a continuation of the fleſhy ones, as is generally ſuppoſed. He found that upon injecting warm water into the crural artery of a lamb of a year old, all the fleſhy fibres loſt their redneſs and become white. He then injected a colour'd liquor into the ſame artery, upon which not only the ſmall arteries appear'd replete with the tinged liquor, but that it had alſo paſſed through each fibre. He alſo obſerved, that ſeveral branches of the arteries now became viſibly ſpread round the ſmall fibrils, and tinged with the ſame liquor; and upon examining the parts of the fleſhy fibres, near the extremity of the arteries with a microſcope, found the ſmall fibrils filled and tinged with the ſame liquor; and not the leaſt appearance of the liquor in the interſtices between the fibrils. And upon injecting another colour'd liquor by the crural artery, he ſaw not only the fibres in ſome of the muſcles, and moſt part of them in others, filled with this matter, but upon examining them in a good

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[1] Phil. Tranſ. No. 339.

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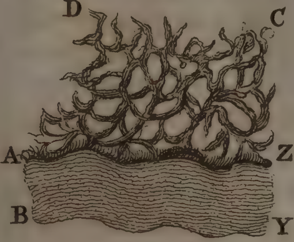

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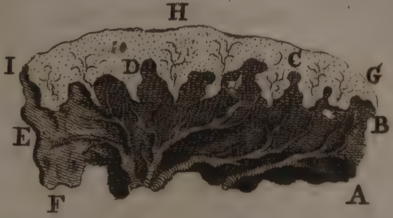

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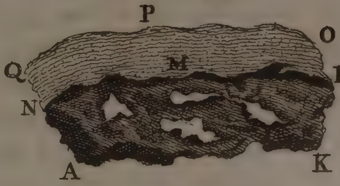

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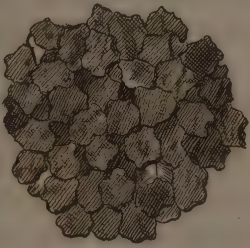

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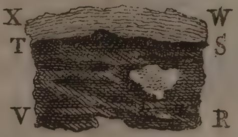

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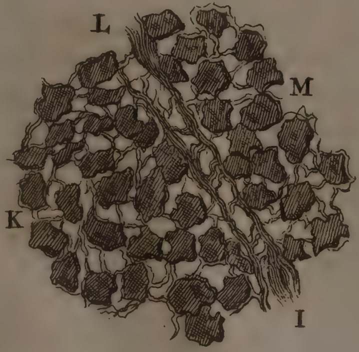

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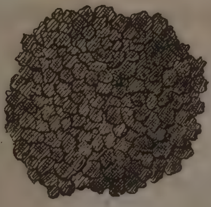

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microſcope, found the fibrils, and even the leaſt tubuli that compos'd them, filled and tinged with the ſame, yet the ſmall ramifications of the nerves appear'd perfectly white. Whence it appears, that the ſmall tubes which form a fibril, are really hollow; and that the extremities of the capillary arteries open into them, and empty therein a part of their liquor, which is re-conveyed by the veins into the heart.

In the ſpinal marrow of an ox, Mr. Leeuwenhoek tells us, he ſaw with great delight minute hollow veſſels of an inconceivable fineneſs, inveſted with their membranes, and extending length-wiſe parallel to each other, make up their compoſition. He did not only diſcern their cavities, which he computed to be three times leſs than their diameters, but in ſome perceived the orifices, as the holes in a prick'd paper are ſeen, when held againſt the ſun. This examination requires the utmoſt dexterity. For after a thin ſlice of the ſpinal marrow is placed before the microſcope, in leſs than a minute's time it becomes dry, and the whole appearance loſt [s].

He alſo examined the brain of an Indian hen, a ſheep, an ox, a ſparrow, &c. and did in them diſtinguiſh multitudes of veſſels extreamly ſmall; and farther [t] obſerv'd, that the veſſels in the brain of a ſparrow are no ſmaller than in an ox, and from thence he argues, that there is no other real difference between the brain of a larger and a ſmaller animal, but only a greater or a ſmaller number of veſſels; and that the globules of the fluid paſſing through them, are in both of the ſame ſize.

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[s] Arc. Nat. Tom. iii. p. 310, 355, 440.

[t] Ibid. Tom. i. Part i. p. 38.

Of Hairs.

FROM Malphigi's curious obſervations of the hair, we are informed, that they are compos'd of a number of extreamly minute tubes, which are moſt diſtinguiſhable near the end of the hairs in a horſe's main and tail, and in the briſtles of a boar, wherein thoſe tubes ſo manifeſtly appear, that he could ſometimes reckon above twenty of them; and in the hedge-hog's prickles, he plainly ſaw thoſe tubes, together with medullary valves and cells.

That which this ſagacious and not enough to be commended obſerver, took notice of in the ſtructure of hair, and its parity to the ſpines, [u] is obſervably true in ſome meaſure in the hairs of cats, rats, mice, and in divers other animals, which look very prettily when viewed with a good microſcope.

Fig. 63. A, B, C, repreſents three cylindrical pieces of human hairs; they are tranſparent throughout their whole [x] length; and are compoſed of ſmall long tubular fibres, encompaſſed with a kind of bark; from which ſtructure, the ends of long hairs when ſplit, appear like a ſtick ſhrivelled with beating, ſome of them in men, horſes, ſheep, hogs, &c. having ſix or more ſplinters.

Fig. 64. repreſents a cylindrical piece of the hair, or briſtle of an hog, which is neither perfectly round nor ſharp edged, but priſmatical, with divers ſides and roundiſh angles.

Part of a whiſker of a cat cut tranſverſly, is repreſented by the ſhort cylinder, fig. 65. which ſeemed ed to have a large pith in the middle, like that of elder.

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[u] Derham's Phiſ. Theſ. p. 220. [x] Hook's Microgra. 1ſt Ed. p. 158.

The hairs of Indian deer appear perforated from ſide to ſide. The long hairs of horſes as at D E F, fig. 66. ſeem cylindrical, and ſomewhat pithy.

The hair of a mouſe ſeems to be one ſingle tranſparent tube, with a pith, made up of a fibrous ſubſtance, running in dark lines, in ſome hairs tranſverſly, in others ſpirally; theſe darker medullary[y] parts are no other than ſmall fibres convolved round; and lying cloſer together than other parts of the hair; they run from the bottom to the top of the hair, and it is apprehended that they run round in a ſcrew-like faſhion. A B, fig. 67. repreſents that part of the hair which grew near the ſkin, the middle part of the ſame hair is ſhewn at C D, and the point of it at E F.

Hairs taken from the head, the eye-brows, the noſtrils the beard, the hand, and other parts of the body, appear unlike, as well in the roots as in the hairs themſelves, and vary as plants do of the ſame genſus, but of different ſpecies.

Hairs have each a round bulbous root, which lies pretty deep in the ſkin, being planted in the pyramidal papillæ, and by this imbibe their proper food from the adjacent humours, and, as hinted above, their extremities ſplit or divide in two or three branches, eſpecially when kept dry, and left to grow too long; ſo that what to the naked eye appears only a ſingle hair, to the microſcope ſeems a bruſh.

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[y] Arc. Nat. Tom. iii. p. 47.

Of the ſcales in the human ſkin.

THE cuticula, ſcarf ſkin, or outward covering of the body, is remarkable for its ſcales and pores.

The ſcales grow upon our bodies, juſt as the ſcales grow upon the external ſkin of a fiſh, [z] and are placed as in fiſhes three deep, i. e. each ſcale is ſo far cover'd by two others, that only a third part thereof appears, as at M, fig. 70. their lying over one another, may be the cauſe why the ſkin of the body appears white; for about the mouth and lips, where they only juſt meet together, and do not fold over, the blood-veſſels are ſeen through, and the parts look red.

The perſpirable matter is ſuppoſed to iſſue between thoſe ſcales, (which lie over the pores or excretory veſſels, through which the watery and oily humours perſpire) and may find vent in an hundred places round the edges of the ſkin.

A piece of ſkin taken from between the fingers, neck, arms, forehead, or any other part of the body which is not hairy, ſerves beſt to ſhew the ſcales: or if they be ſcraped off with a penknife, and put into a drop of water, and ſo applied to the microſcope, they will be ſeen to good advantage, as at L, fig. 70. and generally conſiſt of five ſides.

Mr. Leeuwenhoek tells us 200 of them may be covered with a grain of ſand [a], ſo that if a grain of ſand can cover 200 of thoſe ſcales, it will alſo cover [b] 20,000 places through which perſpiration may iſſue.

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[z] Phil. Tranſ. No. 159. [a] Arc. Nat. Tom. i. Par. II. p. 208. [b] Arc. Nat. Tom. iv. p. 48.

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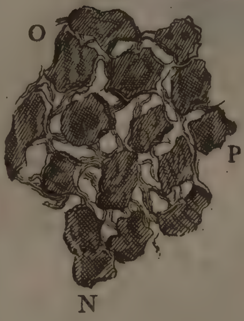

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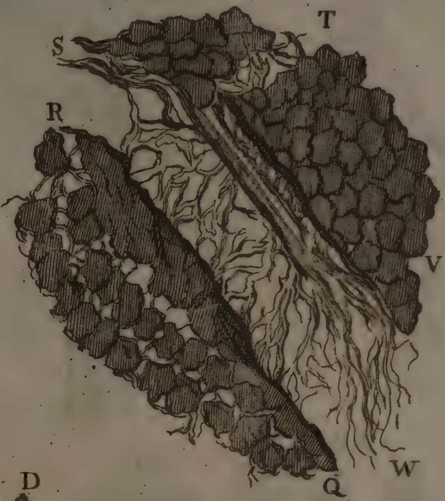

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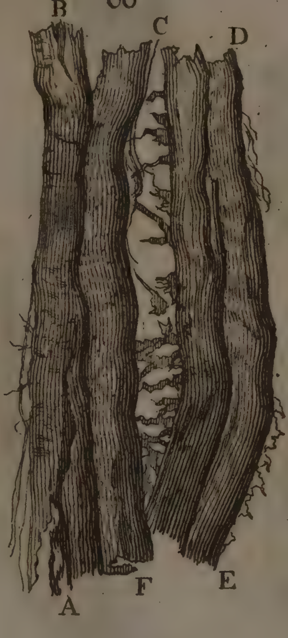

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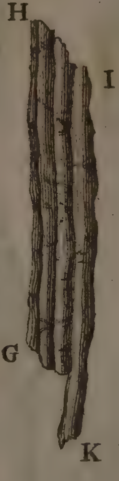

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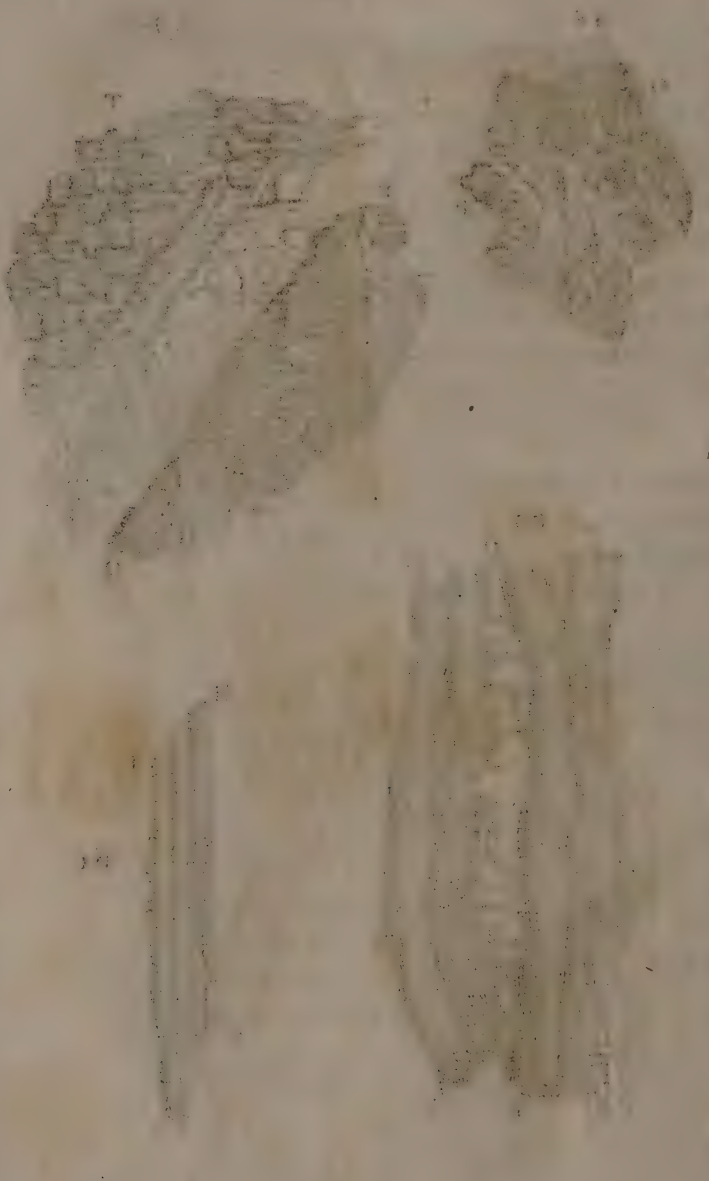

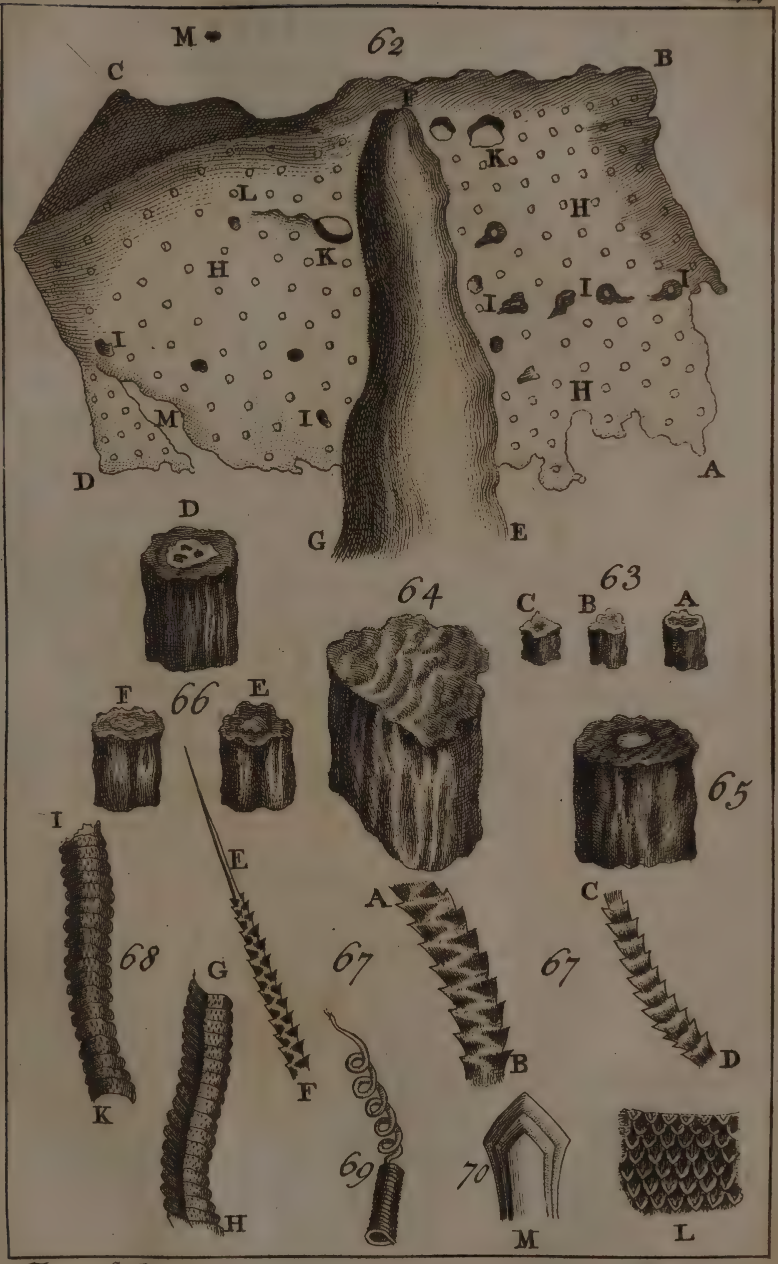

Front.⁹ Pag. 34

Bowles ſc.

To view the pores of the ſkin.

CUT a ſlice of the upper ſkin with a ſharp razor, as thin as poſſible; and then immediately cut a ſecond ſlice from the ſame place, which apply to the microſcope, in a piece about the bigneſs of a grain of ſand, innumerable pores will be perceived. If a piece of the ſkin between the fingers, or in the palm of the hands, be thus prepared, and then examined, the light may very pleaſantly be ſeen through the pores.

The pores through which we perſpire, are moſt remarkable in the hands and feet[c]; for if the hand be well waſhed with ſoap, and examined but with an indifferent glaſs, in the palm, or upon the ends and firſt joints of the thumb and fingers, innumerable little ridges, parallel to each other, of equal diſtance and bigneſs, will appear; upon which the pores may be perceived by a very good eye, but when view'd thro' a very good glaſs, every pore ſeems like a little fountain, with ſweat ſtanding therein, as clear as rock water, and if wiped away, it will be found immediately to ſpring up again.

Of feathers.

THE feathers of moſt ſorts of birds afford a beautiful variety, obſervable in that incomparable curioſity with which every feather is made; the vanes thereof are curiouſly gaged, broad on one ſide, and narrow on the other; both which adminiſter to the progreſſive motion of the bird, as well as to the union and cloſeneſs of the wing; and no leſs exquiſite is the tex-

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[c] Phil. Tranſ. No. 159.

trine art of the plumage alſo, which is ſo curiouſly wrought, and ſo artificially interwoven, that it cannot be view'd without admiration, eſpecially if the eye be armed with a microſcope.

Mr. Hook obſerves, that the make and texture of their downy parts are moſt admirable; for, ſays he, there is ſcarce a large feather, but contains near a million of diſtinct parts, and every one of them regularly ſhaped; with his naked eye he counted 300 of the long downy branches on one ſide, and an equal number on the other ſide, of more ſtiff and ſhorter branches, in a middle ſized gooſe quill, and examining many of thoſe long downy branches with his microſcope, found ſeveral of them to contain near 1200 ſmall leaves, ſuch as A B of fig. 71. and as many ſtalks on the other ſide, ſuch as A C, of the ſame figure; each of theſe branchings A B, ſeemed divided into 16 or 18 ſmall joints, out of moſt of which grew long ſlender fibres, as are expreſſed in the figure, by a b c d, ſeveral of which terminated in a hook; thoſe on the other ſide were much ſhorter, the ſtalks A C were divided into as many knotted joints, but without ſtrings or hooks, being divided at D into two parts, one ſide extended from D towards C, in length equal to A C, the other ſide at D was very ſhort. The tranſverſe ſection of theſe ſtems or branches, were ſhaped like E F G H, whoſe covering appear'd like horn, and the pith like that of the main ſtem of the feather; theſe ſtems or downy branches are ſo ranged, that the leaves or hairy ſtalks of the one, lie at top, or are incumbent on the ſtalks of the other, and croſs each other, much after the manner of fig. 72. by which means, each of thoſe little hooked fibres get between the naked ſtalks, which being full of knots, and a pretty way disjoined, the two parts are ſo cloſely and admirably wove together, as to reſiſt the air; and are ſo extreamly ſmall, that the 500th part of an inch exceeds them in thickneſs.

The parts of the feathers of a peacock, appear through the microſcope no leſs beautiful than the whole feather does to the naked eye; the ſtem of each feather in the tail, ſends out multitudes of lateral branches; ſuch as A B, of fig. 73. which repreſents one thirty ſecond-part of an inch, each of theſe lateral branches emits numbers of little ſprigs or hairs, on each ſide, as C D, C D, C D, each of which in the microſcope appear to conſiſt of a multitude of bright ſhining parts, which are a congeries of ſmall plates, as e, e, e, e, e, &c. each ſhaped like a, b, c, d, of fig. 74. a c being a prominency or ſtem; and d and b the corners of two ſmall thin plates, that grow into the ſmall ſtalk in the middle, making a kind of little feather, and lie cloſe to, or rather upon each other in the manner of tiling; they grow on each ſide of the ſtalk, oppoſite to each other, by two and two, in the manner expreſſed by fig. 75. the tops of the lower ones covering the roots of thoſe next above them; the under ſides of each of theſe plates are very dark and opake, reflecting all the rays caſt upon them; much like the foil of a looking-glaſs; but their upper ſides ſeem to conſiſt of a multitude of exceedingly thin plated bodies, lying cloſe together, and thereby like mother of pearl ſhells do not only reflect a very briſk light, but even tinge that light ſo reflected in a moſt curious manner, which by various poſitions of the light, reflect firſt one colour and then another, in a moſt vivid and ſurprizing manner. And that theſe colours ariſe only from the refraction of light, he found that wetting the colour'd parts with water, deſtroyed their colours, and though he was not able to ſee thoſe hairs at all tranſparent in common light, yet by looking at them againſt the ſun, found them to be tinged with a darkiſh red, not at all reſembling the curious greens and blues they exhibit.

The changeable colour'd feathers of ducks, and ſeveral other birds, he found upon examination with the microſcope to proceed from the ſame cauſes and textures.

The beſt way to apply one of theſe ſmall downy fibres to the microſcope, is to pinch them between the nippers.

Mr. Derham, in his deſcription of the vanes of a flag feather of a gooſe's wing, obſerves theſe two particulars, 1. That the exterior or narrow vanes bend downwards; the interior wider vanes upwards; by which means they catch hold, and lie cloſe to one another, when the wing is ſpread, ſo that not one feather may miſs its full force and impulſe. 2. That the very tips of theſe feathers are alſo neatly ſloped to a point, towards the outer part of the wing; the exterior vanes towards the body.

The vane or web of a feather, conſiſts of ſeveral laminæ, which are thin, ſtiff, and ſomewhat of the nature of a thin quill; towards the ſhaft of the feathers (eſpecially in flag feathers of the wing) thoſe laminæ are broad, and of a ſemicircular form, which ſerves for ſtrength, and alſo for ſhutting theſe plates cloſe to one another, when impulſes are made upon the air. Towards the outer part of the vane, theſe laminæ grow ſlender and taper; on their under ſide they are thin and ſmooth, but are parted into two hairy edges on the upper; each ſide having a different ſort of hairs laminated or broad at bottom, and ſlender and bearded above the other half.

The uppermoſt edge of one of the laminæ, with ſome of the hairs on each ſide, is repreſented in fig. 76. as it appears a little magnified in the microſcope. Theſe bearded briſtles, or hairs, are ſtreight on one ſide thereof, as fig. 77. thoſe on the other ſide have hooked beards on one ſide of the briſtle, and ſtreight ones on the other, as fig. 78. both theſe briſtles magnified (only ſcattering and not cloſe) are repreſented as they grow upon the upper edge of the laminæ ſ t, in fig. 76. and in the vein, the hooked beards of one laminæ, always lie next the ſtreight beards of the next laminæ, and by that means lock and hold each other, and by a pretty mechaniſm, brace the laminæ cloſe to one another. And if at any time the vane happens to be ruffled and diſcompoſed, it can by this eaſy mechaniſm, be reduced and repaired.

Of flies.

THE common fly is an object beautifully ornamented with a mixture of ſilver and black, and thick ſet with briſtles, pointing from its head towards the tail; in its head are two large hemiſpherical eyes, embroidered with ſilver hairs, a wide mouth, an hairy trunk, and a pair of ſhort horns. Its trunk has two parts folded over each other, and ſheathed in the mouth, whoſe extremity is ſharp. In thoſe flies which are of a light colour and more tranſparent than others, the motion of the inteſtines may be plainly ſeen, and alſo the motion of the lungs, as they alternately dilate and contract themſelves.

In general, the female fly is ſupplied with a moveable tube at the end of her tail, by the extenſion of which ſhe can convey her eggs into convenient receptacles, ſuch as may afford a proper nouriſhment to the young. From theſe eggs proceed minute maggots or worms, repreſented in fig. 79. which after feeding voraciouſly for ſome time, arrive to their full growth, and are transform'd into little aurelias, as in fig. 80. whence after a longer ſpace of time, they iſſue forth perfect flies, as fig. 81.

Of the feet of flies, &c.

FIG. 82. A, is a microſcopic repreſentation of the foot of a fly, in which is ſeen three of its joints, the two talons, and the two ſkinny palms or ſoles in a flat poſture. Fig. 82, B, ſhews only one joint, the talons, &c. in another poſture, which is ſo admirably and curiouſly contrived, as to enable the flies to walk againſt the ſides of glaſs, and to ſuſpend themſelves under the ſurface of a ceiling, with the greateſt ſeeming facility and firmneſs. The two talons A B, A C, are very large in proportion to the foot; the biggeſt part of them from A to I I, is all hairy, their points C and B ſmooth, and bending inwards. Each of theſe talons are jointed at A, ſo that the fly is able to open and ſhut them at pleaſure: the claws readily enter the pores of moſt ſubſtances, at which time, as the fly endeavours to ſhut them, the claws C B, do not only draw towards, but fix each other; and alſo draw the whole foot G G A D D forward; ſo that on a ſoft body, the points G G G G (of which the fly has about ten to each foot) enter. This is ſenſible to the naked eye, in the feet of a chaffer, and if you ſuffer him

to creep over the hand, he makes his ſtep as ſenſible to the touch alſo.

But as this contrivance often fails the chaffer, ſo would it the fly, had not nature furniſhed his feet with another curious contrivance, which is the palms or ſoles D D. They are two ſmall, thin, flat, and horny ſubſtances, that ariſe from the under part of the laſt joint of the foot, and are ſeemingly flexible; ſo that their two ſides do not always lie in the ſame plane, but may be ſhut cloſer, and as it were graſp a body of themſelves: beſides, the under ſides of theſe ſoles are all beſet with ſmall briſtles, like the wire teeth of a card, whoſe points tend forward. Hence the talons drawing the feet forward as before, and theſe ſoles being applied to the ſurface of the body, with all its points looking the contrary way, if there be any irregularity, or yielding therein; the fly ſuſpends itſelf very firmly and eaſily. That the fly is enabled to walk on glaſs, proceeds partly from a ruggedneſs of the ſurface, or a kind of tarniſh or dirty ſmoaky ſubſtance, adhering to the ſurface of that very hard body; and though the pointed parts cannot penetrate, yet they may find pores enough in the tarniſh, or at leaſt make them. This ſtructure Mr. Hook ſurveyed with great diligence, becauſe he could not comprehend, that if there was any ſuch glutinous matter in thoſe ſuppoſed ſponges (as moſt that have obſerved that object in a microſcope, have believed) how the fly could ſo readily unglew and looſen its feet; and alſo becauſe he had found no other creature any ways like it.

A contrivance nearly alike to this is to be found in all kind of flies, and caſe-winged inſects, and in the flea, in mites, &c. ſome of which have only one ſharp talon at the end of each leg, which drawing towards the center or middle of their bodies, enable theſe exceeding light bodies to ſuſpend and faſten themſelves to almoſt any ſurface. This will not ſeem ſtrange, if we conſider firſt how ſmall their bulk is when compared to their ſuperficies, their thickneſs frequently not amounting to the 100th part of an inch. Secondly, their ſtrength and agility, compared to their bulk, which in that proportion perhaps may be an hundred times ſtronger than an horſe. Thirdly, if we conſider that nature always appropriates the inſtruments in the moſt fit, eaſy, and ſimple manner poſſible to perform their office; which is alſo verified in the foot of a louſe, each of his legs being footed with two ſmall claws, with which it graſps and thereby moves itſelf to and fro upon the hairs of the creature it inhabits.

The legs of flies are beſt applied to the microſcope, by being either ſtuck upon the point, or held between the nippers. Though we frequently place them between two talcs in an ivory ſlider.

Of the eyes and head of a grey drone fly.

THE ſtructure of the eye in all creatures, is an admirable piece of mechaniſm; but the beautiful contrivance of the eyes of inſects is ſo peculiar, that it muſt excite our admiration; ſo fenced with its own hardneſs, that its own accurate viſion is a good guard againſt external injuries; its outward coat being all over beſet with curious lenticular inlets; enabling thoſe creatures to ſee very accurately every way, without any interval of time, or trouble to move the eye towards objects [d].

See fig. 83. This fly was made choice of, becauſe the inquiry being chiefly about the eyes, it was found to have

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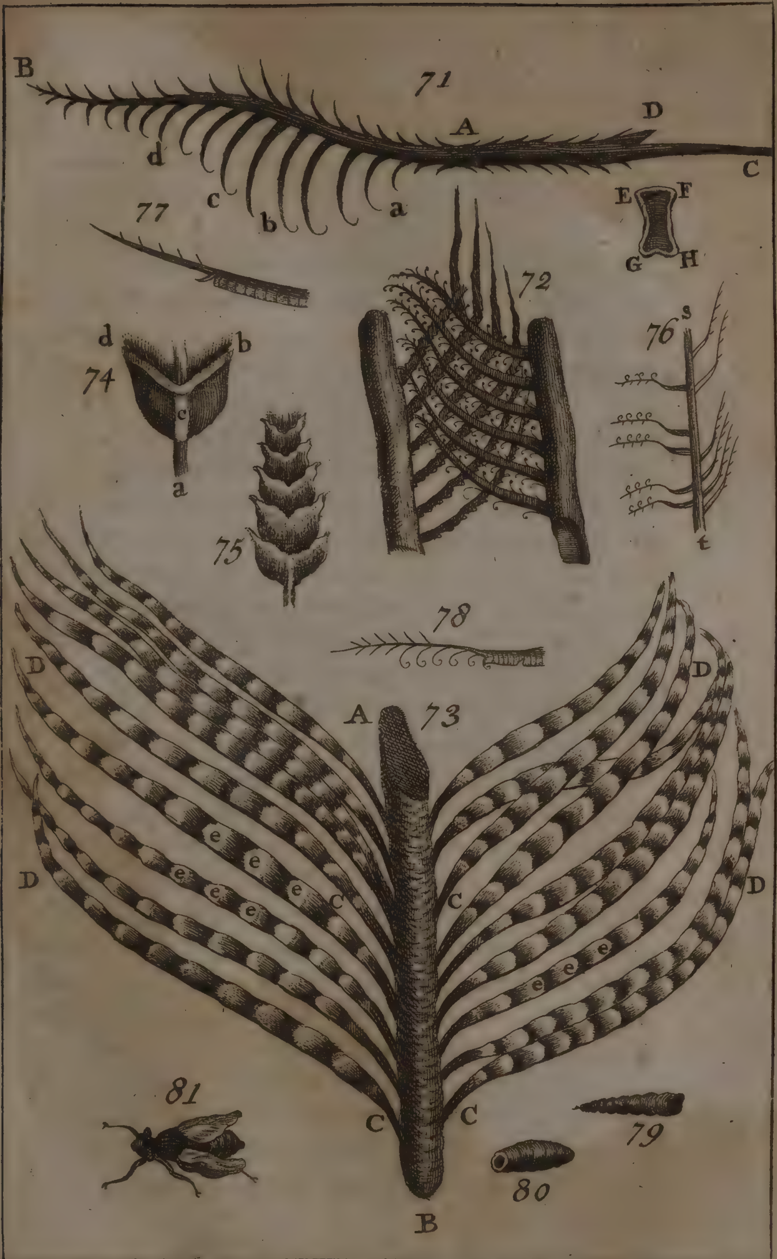
[d] Derham's Phy. Theo. p. 171.

Pl. 23



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Bowles sc.

have the biggeſt cluſter of eyes, in proportion to its head, of any other ſmall fly; it inclining ſomething towards the make of the large dragon fly, which is the moſt remarkable of all other inſects for its fine pearled eyes.

The greateſt part of the head was nothing elſe but two large protuberances, A B C D E, whoſe ſurface was covered over with a multitude of ſmall hemiſpheres, placed with the utmoſt regularity in rows, croſſing each other in a kind of lattice-work.

That half of them C D E, C D E, which looked towards its legs, were obſerved to be ſmaller than the other half A B C E, A B C E, which looked upwards and ſideways. The ſurface of theſe hemiſpheres were ſo exceeding ſmooth and regular, that in each of them Mr. Hook was able to diſcover a landſcape of thoſe things which lay before his window, part of which was a large tree, whoſe trunk and top he plainly ſaw. Alſo the motion of his hand and fingers, if moved between the object and the light. Theſe rows of eyes was ſo diſpoſed, that no object was viſible from his head, but ſome of theſe hemiſpheres were directed againſt it: and further, that where the trunk of the body ſeem'd to hinder the proſpect, theſe protuberances were elevated, ſo that a fly may be truly ſaid to have an eye every way. Theſe little hemiſpheres have each of them a minute tranſparent lens in the middle, each of which hath a diſtinct branch of the optick nerve miniſtring to it, and rendering it as ſo many diſtinct eyes; ſo that as moſt animals are binocular, flies, beetles, &c. are multocular, having as many eyes as there are perforations in their cornea [e]. By which means as other creatures are obliged to turn their eyes to objects, theſe have ſome of their eyes ready placed towards objects nearly all round them.

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[e] Derham's Phy. Theo. p. 372.

Two of theſe optick nerves are repreſented as delineated by Mr. Leeuwenhoek, in fig. 84. And in fig. 85. are exhibited[f] a great many of them in a cluſter, as they appeared before the microſcope, whereof that part of them which was ſituate next the cornea is ſhewn by the letters N O P; it is alſo obſervable, that thoſe nerves, which were neareſt to the circumference of the cornea, were ſhorter than thoſe next within them, and ſo on, till they arrive at the central nerve, which is the longeſt of all.

The number of the pearls in this fly, Mr. Hook reckon'd to be 14000. Mr. Leeuwenhoek computed 6236 in a ſilk-worm's two eyes, when in its fly ſtate; 3181 in each eye of a beetle; and 8000 in the two eyes of a common fly.

Cut off the eye of any fly, and with a pencil, and ſome clean water, waſh out all the veſſels, thoſe veſſels may be examined by the microſcope, and then if you carefully dry the outward covering, ſo as not to let it ſhrink, it will be rightly prepared for making experiments; and upon viewing it, we ſhall diſtinguiſh the numerous protuberances or hemiſpheres divided from one another with a ſmall light, iſſuing between them, and ſix ſides to each. Mr. Leeuwenhoek having prepared an eye in this manner, placed it a little farther from his microſcope than when he would examine an object, ſo as to leave a right and exact focal diſtance between it and the lens of his microſcope; and then look'd through both, in the manner of a teleſcope, at the ſteeple of a church, which was 299 feet high, and 750 feet from the place where he ſtood; and could plainly

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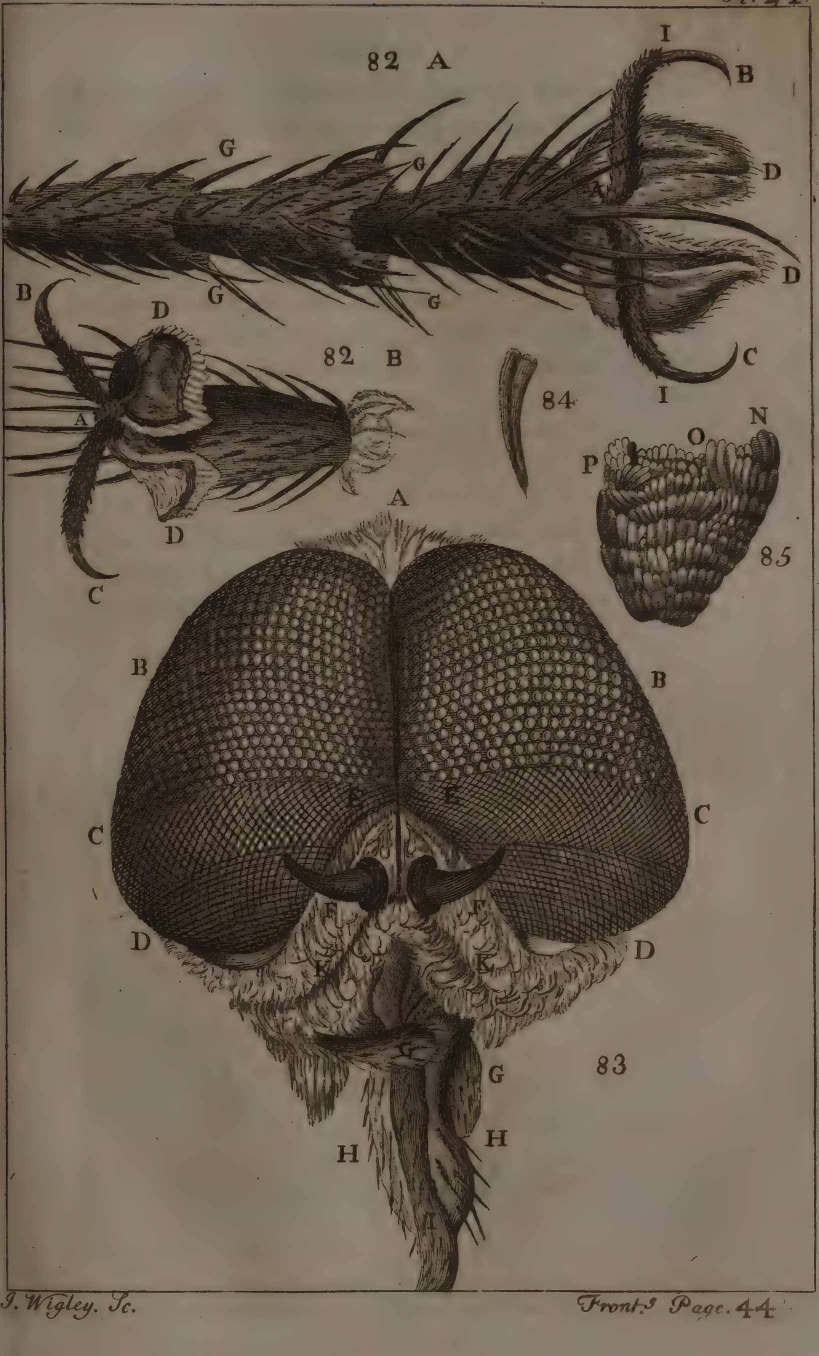
[f] Arc. Nat. Ep. 111.



J. Wigley. Sc.

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plainly ſee through every little lens, the whole ſteeple inverted, though not larger than the point of a fine needle; and then directing it to a neighbouring houſe, ſaw through abundance of the little hemiſpheres, not only the front of the houſe, but alſo the doors and windows, and was able to diſcern diſtinctly whether the windows were open or ſhut.

An eye of a fly thus prepared, may be held between the nippers for examination. But the head of any fly is beſt ſeen when ſtuck upon a piece of card, with ſome ſtrong gum water, and applied to the microſcope under the ſilver reflector, which piece may be held in the nippers.

N. B. The horns F F, the feelers G G, the proboſcis H H, and the hair and briſtles K K, ſhall be hereafter deſcribed.

Of the wings of flies.

THE wings of all kinds of inſects afford an infinite variety, no leſs agreeable to the mind, than pleaſing to the eye; being diſtended and ſtrengthened by the fineſt bones, and cover'd with the lighteſt membranes. Some of them are adorn'd with neat and beautiful feathers, and many of them provided with the fineſt articulations and foldings, for the wings to be withdrawn, and neatly laid up in their vaginæ and caſes, and again readily extended for flight.

This of the blue fly, fig. 86. here exhibited, is not without its peculiar ornaments; it grows out of the middle part of the body of the fly, and is ſeated a little beyond the center of gravity thereof, towards the head; but that is curiouſly ballanced by the expanded area of the wing, which conſiſts of ſeveral bony ribs, that gave ſtrength to the filmy parts; which are thickly beſet with innumerable ſmall briſtles, intermixed with as many dark ſpots, which ſeem to be the roots of the hairs that grow on the other ſide.

Of other flies, ſome of their wings are filmy, as the dragon flies; others ſtuck over with ſhort briſtles, as the fleſh fly; others have divided wings, as the grey and white feather'd moths; many ſorts of gnats wings are adorned with rows of feathers along their ridges, and borders of feathers round their edges; ſome have hairs, and other hooks, placed with the greateſt regularity and order. In the butterfly and ſome moths, there are an infinite number of ſmall feathers, which cover both the under and upper ſurfaces of this thin film, not only ſhaped much like the feathers of birds, but alſo variegated with the greateſt variety of curious bright and vivid colours; which is evident to the naked eye, but much more entertaining when view'd through the microſcope; by which we are informed, that theſe curious colour'd minute feathers end in quills, and are placed in orderly rows with great exactneſs, as the holes they come from ſhew when they are rubb'd off.

Fig. 87. repreſents a ſmall piece of a butterfly's wing; A B ſhews one of thoſe bony ribs that gives it ſtrength, along whoſe ſides are ſuppoſed to branch out various blood-veſſels, conveying nouriſhment to the intermediate parts; although no circulation can be diſcern'd therein, we can ſcarce doubt but that a continual ſupply of juices muſt be carried on to theſe minute quills, hairs, and briſtles; C, C, C, exhibits three of theſe ſingle plumes, with their quills adhering to the tranſparent membrane of the wing, in which membrane G, G, G, when diveſted of its feathers, may be ſeen the orders of pits or holes where the quills are rooted, and from whence they ſhoot; D, E, F, ſhews a few of the feathers exactly in the form as they cover the whole wing.

Some flies have hairs, and all the ſcarab kind have elytra, or caſes, into which their wings are folded and preſerved, till they want to employ them, as in fig. 110. ſome of theſe caſes reach almoſt to the extremity of thair tail, as in moſt kinds of beetles; and in others are very ſhort, as in the earwigg. They do by a very curious mechaniſm extend and withdraw their membraneous wings. It is very curious to ſee them prepare themſelves for flight, by thruſting out, and then unfolding their wings; and again withdraw thoſe joints, and neatly fold in the membranes, to be laid up ſafe in their elytra or caſes; for which ſervice the bones are admirably placed, and the joints miniſtring thereto are accurately contrived for the moſt compendious and commodious folding up of the wings.

Mr. Hook hath obſerved the motion of theſe filmy wings in ſome minute ſpinning flies, which naturally ſuſpend themſelves as if pois'd and ſteady in one place of the air, in which by a faint ſhadow he could perceive the utmoſt extremes of the vibrative motion; which ſhadow, while they endeavour'd to ſuſpend themſelves, was not very long; but when they endeavour'd to fly forward, it was ſomething longer; he alſo fixed the legs of a fly with glew or wax upon the top of the ſtalk of a feather, and then making it endeavour to fly away, was thereby able to view it in any poſture; and found the motion of the extreme limits of the vibrations, to be about the length of the body diſtant from each other; and concluded by the ſound, that the wing was moved forwards and backwards with an equal velocity, (and comparing it with a muſical ſtring tuned uniſon to it) the vibrations whereof are ſo ſwift, that it is probable there are many hundred, if not thouſand vibrations in one ſecond of time, and ſuppoſes them the ſwifteſt vibrations in the world; whence he reflects on the quickneſs of the animal ſpirits, which ſerve to ſupply this motion.

It is obſervable that moſt inſects are provided with a little ball,[g] or bladder, under each wing, fix'd at the top of a ſlender ſtalk, moveable every way at pleaſure; in ſome they ſtand alone, in others (as in the whole fleſh fly tribe) they have little covers, under which they lie and move; with theſe poiſes, and ſecondary leſſer wings, they obviate all the vacillations of their body, and poiſe it in flight, as a rope-dancer ballances himſelf by his pole loaden at each end with lead.

If one of theſe be cut off, the creature flies aukwardly for a while, and at laſt falls to the ground. Theſe bladders being hollow, may ſerve likewiſe to produce the noiſe many ſorts of flies make by ſtriking their wings againſt them; inſects that have four wings ballance themſelves with the two leſſer ones.

The wings of flies are beſt applied to the microſcope between two Muſcovy talcs, in an ivory ſlider.

If with an hair pencil, or point of a penknife, you gently bruſh or ſtroke off ſome of the minute feathers from the wings of butterflies, and ſome ſort of moths, then breathe upon a ſingle talc in one of your ſliders, and apply it to the feathers, which ſeem only like a fine duſt, they will immediately adhere to it; if upon their application to the microſcope they lie not to your mind, wipe them off, and put on others in the ſame manner, till they lie fair for examination, then cover them with another talc, and faſten them down with a ring.

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[g] Derham's Phy. Theo. p. 377.

Of a blue fly.

FIG. 86. repreſents a microſcopical picture of this fly; it has many things about it worthy of note; ſeveral of which are already deſcribed, viz. the head, the eyes, wings, and feet.

The cluſters of eyes in this fly are much ſmaller than that of the drone fly in proportion to its head. Between theſe two cluſters of eyes appeared a ſcaly prominency B, armed and adorned with black briſtles, ſharp, and tapering, growing in rows on either ſide, and bending towards each other, formed a kind of briſtly arbor, which almoſt covered the fore front; at the end of this arch, and about the middle of the face on a riſing part C, grew two oblong bodies D D, which through the microſcope looked not unlike the pendants of lillies, and appeared to be jointed on two ſmall parts at C, each of which ſeemed again jointed into the front. Out of the upper part of each of theſe horns grows a feather, or bruſhy briſtle E E, on the under part of the face F F, were ſeveral of the former ſort of bended briſtles; and below all is the mouth, out of which grew the proboſcis G H I; which by means of ſeveral joints, the fly was able to move to and fro, and to thruſt in and out as it pleaſed. The end of this hollow body, which was covered over with ſhort hairs, ſeemed bent at H, and the foremoſt ſide of the bended part ſlit into two chaps [h] H I, H I. Theſe he could open and ſhut very readily, and when he ſeemed to ſuck any thing from the ſurface of a body, he would ſpread thoſe chaps, and apply the hollow part of them cloſe to it.

From

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[h] Hook's Micro. p. 183.

From either ſide of the proboſcis, within the mouth, grow two ſmall horns K K, which were hairy and ſmall in this figure, but of another ſhape, and bigger in proportion in fig. 83. where they are marked G G, which two are generally called, the antennæ, or horns of inſects. Mr. Derham imagines them to be obſolutely neceſſary to the ſearching out and finding their way [1], as their eyes are immoveable; ſo that no time is required for their turning them to objects; there is no neceſſity that the retina, or optick nerve, ſhould occaſionally be brought nearer to, or removed farther from the cornea, as it is in other animals; but their cornea and optick nerve being always at the ſame diſtance, and fitted only to ſee diſtant objects, they would be inſenſible of, and apt to run their heads againſt bodies very near them, were they not aſſiſted by their feelers: and that this, rather than wiping the eyes, as ſome have imagined, is the particular uſe of the feelers, and is apparent from the fleſh fly, and many other inſects, which have their antennæ ſo ſhort and ſtreight, as not to be capable of being bent unto, or extended over the eyes.

The middle part of this fly was caſed with a firm coat of armour, the upper part of which was thickly beſet with conical briſtles, pointing backwards; from its under part ſprang ſix legs, three of which are apparent in the figure at M, N, O; they were all of the ſame ſtructure, being covered with an hairy ſhell, and compoſed of eight joints, to the laſt of which grew the ſoles and claws before deſcribed in pag. 40. From the upper part of the trunk grew the two wings, which are deſcribed pag. 45; the hinder part of his body was of a moſt curious ſhining blue, and exactly like poliſhed ſteel, brought to that colour by nealing.

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[1] Derham's Phy. Theo. p. 372.

The lamellated antennæ of ſome, the cavelated of others, the neatly articulated and the feathered or tufted of others, are exceedingly beautiful when viewed through a microſcope.

And in ſome theſe antennæ diſtinguiſh the ſexes [k], for in the gnat kind all thoſe with tufts, feathers, or bruſh horns, are males; and thoſe with ſhort ſingle ſhafted antennæ, are females.

Flies of any kind may be examined in the microſcope, by ſticking them upon the point, or pinching any part of them between the nippers, and ſo applied to the magnifier under the reflecting concave, if it be opake. And if you are deſirous to keep its head, or any other part, it may be ſtuck with gum water upon a piece of card.

It is very obſervable, that inſects take particular care to depoſite their eggs or ſeed in ſuch places, where they may have a ſufficient incubation, and where the young, when hatched, may have the benefit of proper food till they become able to ſhift for themſelves. Thoſe whoſe food is in the water, lay their eggs in the water; thoſe to whom fleſh is a proper food, in fleſh; and thoſe to whom the fruits or leaves of vegetables are food, are accordingly repoſited, ſome in this fruit, ſome in that tree, and ſome in that plant, and ſome in another, but conſtantly the ſame kind in the ſame tree, &c.

As for others that require a more conſtant and greater degree of warmth, they are provided by the parent animal with ſome place in or about the body of other animals; ſome in the feathers of birds, ſome in the hair of beaſts, ſome in the ſcales of fiſhes, ſome in the noſe, ſome in the fleſh, nay ſome in the bowels and inmoſt receſſes of man, and other creatures. And as for others, to whom

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[k] Derham's Phy. Theo. p. 373.

none of theſe methods are proper, they make them neſts by perforation in the earth, in wood, in combs, and the like, carrying in, and ſealing up proviſions, that ſerve both for the production of their young, and for their food when produced.

In flies, butterflies, &c. it is obſerved there is a kind of gluten, by which the female faſtens her eggs to the bearing buds of trees, &c. ſo that the rains cannot waſh them off, nor the ſevereſt froſt hurt them.

Of inſects that infeſt fruit and other trees.

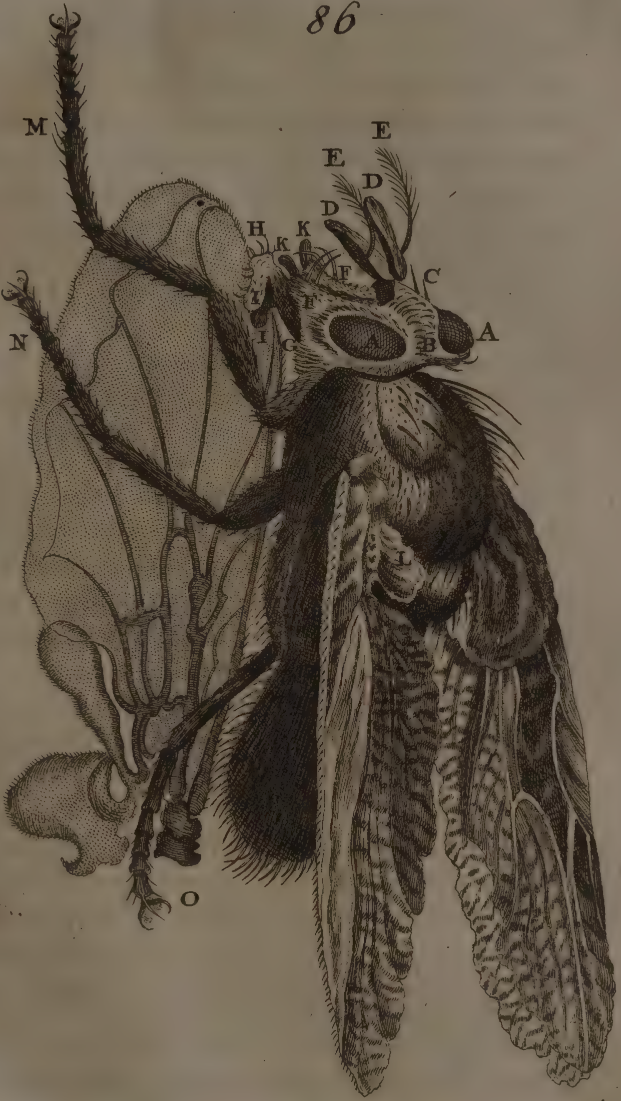
THESE inſects are of the ichnumon fly tribe; that generated in the plumb, is black, of a middle ſize, its body near three tenths of an inch long, its tail not much leſs, conſiſting of three briſtles, wherewith it conveys its eggs into fruit, its antennæ long, ſlender, recurved; its belly longiſh, tapering, ſmall towards the thorax, legs reddiſh, wings membraneous, thin and tranſparent, in number four.

The bloſſoms of apples and quinces are infeſted with multitudes of ſmall animals, ſo likewiſe are the green leaves of gooſe-berry, currant, cherry, grape, plumb, and other trees, overſtocked with infinite numbers of theſe minute flies. Some blackiſh, others green, ſome winged, others without wings; ſeveral of which bring forth their young alive and perfect; for if their bodies be opened, ſeveral imperfect embrio's may be found therein. Alſo inſects of a greeniſh colour of the ſhape of fig. 88. but no bigger than a grain of ſand when firſt hatched, which at full growth appear to the naked eye of the ſize of fig. 89.

Theſe

Pl. 25

86



Front.^e Pag. 52

Bowles ſc.

Theſe little inſects Leeuwenhoek calls pediculus [1], or louſe, who on plucking a leaf from a plumb-tree, and putting it into ſuch a glaſs tube as has been already deſcribed, which he applied to his microſcope, and found thereon 36 black flies, and ſeveral hundred of theſe green lice, and among them many which were but juſt hatched. In a ſhort time theſe green lice died, and from their carcaſe came forth a black fly. Fig. 88. repreſents the carcaſe of one of the green lice as it appeared before the microſcope. The ſhell or ſkin of its back had ſeveral rows of knobs upon it; its eyes A B were like thoſe of other flies; C D ſhew its two antennæ articulated and ſet with hairs. E F G H I K ſhew the legs, having at their extremity two hooked nails, and ſhort hairs. L M repreſents the aperture, from whence came out the worm, from which the fly was produced, having firſt eaten up all the inſide of the body of the green louſe.

Fig. 90. exhibits one of the minute black flies thus produced from a worm, which had increaſed itſelf by deſtroying its foſter parent, and then changed into a nymph, and at laſt from that to a fly, furniſhed with all thoſe minute organs as are expreſſed in the figure; whereof A B ſhews its two eyes, C D its antennæ, which afford a pleaſant ſight in the microſcope, its curious joints being finely beſet with hairs.

E F are two organs, through which it ſucks its nouriſhment, its long tail G H I, K L M N, its four wings bedecked with exceeding fine hairs and a much finer membrane, O O O O O O its ſix feet, which were alſo furniſhed with many joints, and thickly ſet with hairs. The letters P Q R expreſs the point of the nippers which held the fly before the microſcope. Theſe lice are alſo to be

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[1] Arc. Nat. Ep. 135.

be found upon the leaves of filberd-trees, with this difference, the former being green, and the latter white.

Upon the leaves of apples and other trees, are found a curious fly [m], the exquiſite make and form of its parts are not to be diſcerned without a microſcope. Fig. 91. repreſents the ſize and ſhape it appears of to the naked eye, and fig. 92. a part of its head, whereof A B are its two protuberant eyes, C D E its ſnout, furniſhed with various forceps or teeth, with which it perforates the buds of fruit and flowers; this ſnout is flexible and capable of bending every way, C F and D G are the two horns which adorn the ſnout. Fig. 93. is almoſt a fourth part of the leg of this fly, which conſiſts of four joints. H I are two nails which appear in the microſcope, as horn does to the naked eye, and K L ſhews its two ſkinny palms or ſoles.

There is another ſort of animalcula found in the wrinkles and wreathed curls of blighted leaves [n], and in the extremity of the ſprouts of leaves, as in garden currants, cherries, peaches, nectarines, &c. may be found great ſwarms of theſe minute inſects, no bigger than an half-grown louſe, one of which is repreſented by fig. 94. of its full growth, and of the ſize it appeared of to the naked eye. Fig. 95. ſhews the ſame magnified and near its laſt change, the folded wing juſt beginning to appear at A B. It had ſix ſmall jointed feet, fenced with ſhort hairs, and two nails on each; C ſhews one of its eyes, which was of a ſurprizing make. D F repreſents the proboſcis, with which it perforates the leaves and buds of trees, and then thruſts out its Dart E and ſucks their juice. From its tail proceeds two upright parts G H, out of which a tranſparent liquor is frequently diffuſed

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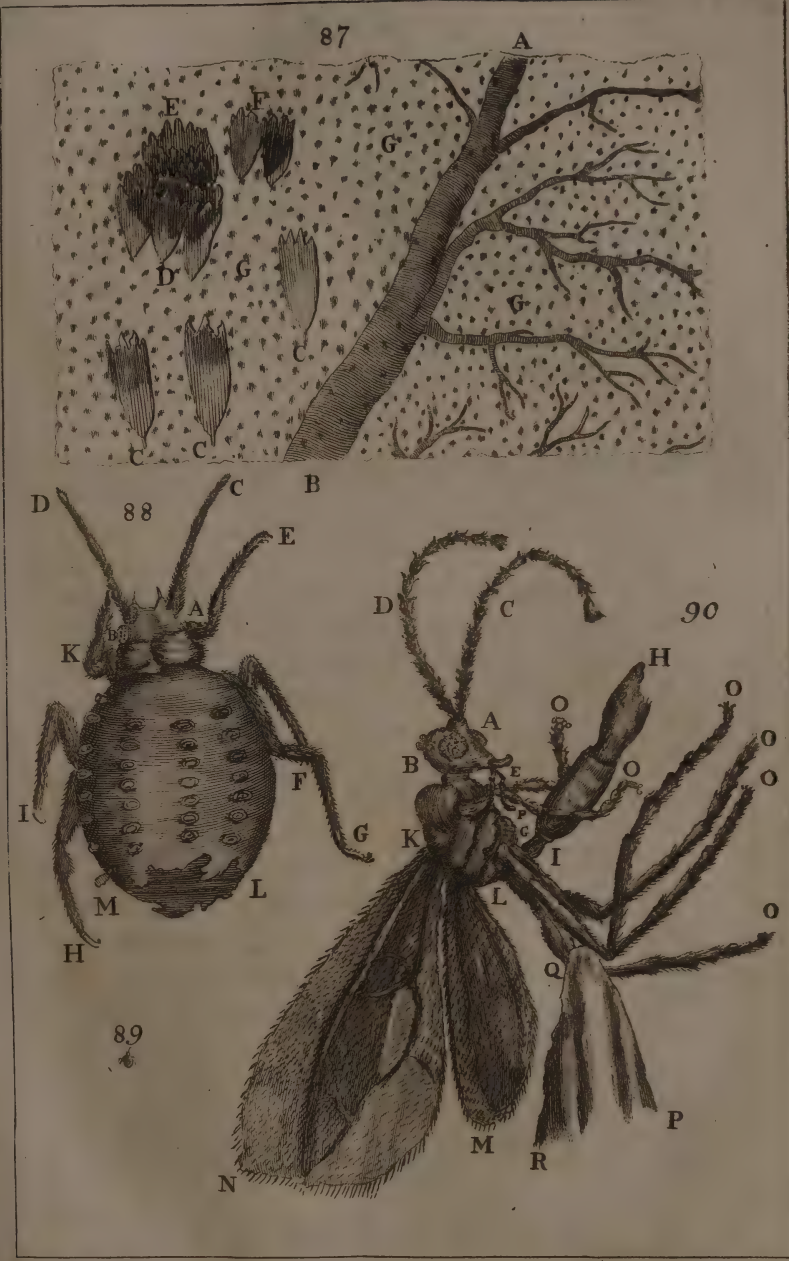
[m] Leeuwenhoek Ex. & Con. Epiſt. 89.

[n] Leeuwenhoek Ex. & Con. Epiſt. 90.

Pl. 26.



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diffuſed as at H. I K L is the needle's point, upon which the animal was ſtuck; and fig. 94, as before hinted, the ſame animal when changed into a fly.

Mr. Derham could never obſerve any other kind of fly but the leſſer phalenæ [*] about four tenths of an inch long, to be bred in pears and apples; it is whitiſh underneath, greyiſh brown above, ſpotted about one third with waves of a gold colour, its head ſmall, a tuft of whitiſh brown on its forehead, and antennæ ſmooth. The aurelia of this moth is ſmall, and of a yellowiſh brown.

Of excreſcencies growing on willow-leaves, and a ſmall fly bred thereon.

MR. Leeuwenhoek frequently diſcovered more than one ſort of worm upon opening the knotty part of willow-leaves, and having put ſeveral of theſe knots, whoſe contained worms were not full grown, into a large glaſs tube, that the worms might attain their full growth, could not find that any of them did ſo; obſerving at the ſame time ſeveral of theſe knots to have none of the worms in them, but almoſt full of the ecrements of the worms which had been therein, and were diſlodged, through a ſmall hole he could perceive in the knots.

Fig. 96. A B repreſents a willow-leaf, in which are ſeveral excreſcencies, ſome of them with holes as F, others as C D E; G H ſhews two of theſe knobs cut open, and the poſture of the worm therein, ſeveral worms lay dead in the knobs ſuppoſed to be killed by other leſſer worms, produced from an egg depoſited by another fly ſince

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[*] Phy. Theo. p. 387.

ſince the production of the former, which devoured and lived upon the larger worm.

In the middle of July Mr. Leeuwenhoek cropt ſeveral willow-leaves, in which were ſuch like knobs [p], and diſcovered ſeveral worms nearly arrived to their full growth: after theſe knobs had been in the glaſs tubes about eight days, upon opening one of them he found, that the worm was turned into a tonnekin or aurelia, and in ſome others thirteen or fourteen more of the ſame. In ſome of the knobs he found the ſmall devouring worms above-mentioned, being ſo far advanced in growth that they were ready to be changed into flying inſects; he put theſe alſo in glaſs tubes. After ſome weeks certain black flies proceeded from thoſe tonnekins, their hinder parts of an oblong figure, and faſhioned like a hook. He alſo ſaw two of theſe ſmall worms (which devoured the large ones) endeavouring to encloſe themſelves in a web; but by reaſon of the large ſpace in which they lay, could not bring it quite round them, having made it only on one ſide, and their change happened in ſo ſhort a time that he could not make his remarks thereon.

Fig. 97. repreſents the aforeſaid fly as it appears to the naked eye. A B ſhews the long, ſlender, and hooked part; on examining this little inſtrument in the microſcope, it appeared to be hollow, and was covered with a great number of fine hairs, as in fig. 98. and on endeavouring to ſplit it, the dart, fig. 99. appeared, whoſe point is only jagged with ſaw-like teeth, which being alſo ſplit, two other diſtinct hooks [q] were taken out of it both of the ſame ſhape, a ſmall part of one of them is repreſented by fig. 100. each of them being fortified with ſaw-like teeth, and the dart fig. 101, was found to be only a ſecond caſe or ſheath for the two hooks, wherein the hollowneſs does plainly appear, which is filled with a corroſive water. The fly makes uſe of this auger to prepare a convenient lodgment for her eggs (and chooſes thoſe leaves that are moſt lacteous and juicy) under the ſkin of the leaf, from whence the worm upon gnawing the veſſels for its ſuſtenance, occaſions the ſap to flow out of them and to coagulate into that knotty ſubſtance. Mr. Leeuwenhoek took a ſmall devouring worm from a larger that lay dead by it, and put it upon a living one to which it immediately faſtened, whilſt the other at the ſame time uſed all means, by bending, ſtretching, contracting, and winding its body, to free itſelf from this troubleſome gueſt, but in vain, the ſmall one ſtill keeping its hold.

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[p] Phil. Tranſ. No. 269.

[q] Arc. Nat. Epiſt. 136.

Fig. 102. exhibits a tonnekin, which was a worm but the foregoing evening, and had caſt off a very thin ſkin; this alſo conſiſted of ſeveral rings and circles as when in the worm ſtate. The feet and joints thereof were very viſible; A B and A C repreſents its two antennæ; and although they were incloſed in a thin membrane, yet all the joints might be clearly ſeen. The change of this worm was ſo ſudden, that Mr. Leeuwenhoek was never able to ſee it.

Not only the willows and other trees, but plants alſo have caſes produced on their leaves, as nettles, ground ivy, &c. by the injection of the eggs of an ichneumon fly. Theſe caſes are generally obſerved to grow near to ſome rib of the leaf, and their production thus. The parent inſect with its ſtiff ſetaceous tail, terebrates the rib of the leaf when tender, and makes way for its egg, into the very pith or heart thereof, and probably lays in therewith ſome proper juice of its own body to pervert the regular vegetation of it. From this wound ariſes a ſmall excreſcence which (when the egg is hatched into a maggot) grows bigger and bigger, as the maggot increaſes, ſwelling on each ſide the leaf between the two membranes; and extending itſelf into the parenchymous part thereof, until it grows as big as two grains of wheat: in this caſe lies a very ſmall white rough maggot, which turns into a beautiful green ſmall ichneumon fly.

Of the crane-fly, or father long-legs.

THIS little creature, though but ſeldom taken notice of, affords an agreeable variety of ſubjects, when examined by the microſcope. It is produced from a worm hatched in an egg, depoſited by its parent under the graſs in meadows.

Theſe worms are to be met with but in the hot weather upon the ground under the graſs in the meadows and fields. Fig. 103. repreſents one of them, which could not be diſcerned to change or increaſe between the months of May and Auguſt [r]. Fig. 104. ſhews the worm changed into a nymph, and at its firſt coming forth greatly agitated. Fig. 105. ſhews the caſt-off ſkin, which in its change the worm forſook, after which it took wing and flew away in the form of fig. 106. which repreſents one of theſe male flies, as does fig. 107. alſo ſhew the female.

The tails both of the male and female are of a curious ſtructure, that of the female is ſharp, and of the conſiſtence of bone, wherewith ſhe perforates the ground, and depoſites her eggs under the graſs in a moiſt place. This acute tail of the female is ſhewn at N, fig. 107. which ſhe can open into four diſtinct parts [s]. Upon opening

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[r] Leeuwenhoek Ex. & Contemp. p. 347.

[s] Leeuwenhoek Ex. & Contemp. p. 349.

Pl. 27

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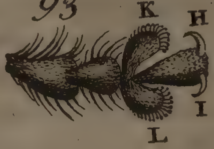

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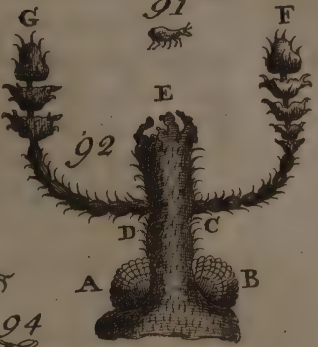

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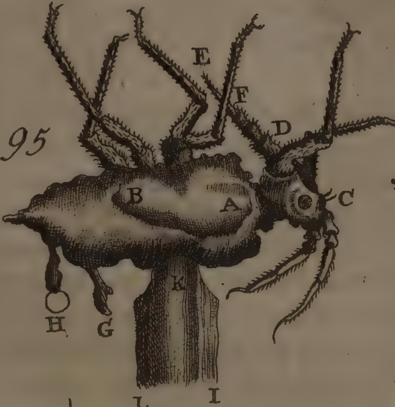

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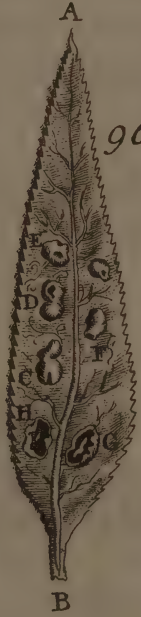

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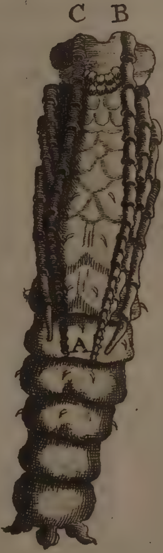

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opening one of theſe females Mr. Leeuwenhock counted upwards of two hundred eggs of a blackiſh colour and ſmooth, like poliſhed glaſs, and about twice as long as they were thick. The inteſtines of this little creature are alſo very curious, which when opened with unſpeakable admiration he ſaw them by the aſſiſtance of the microſcope, as plainly as the bowels in larger animals can be ſeen by the naked eye.

In the feet of this fly, if diſſected in a drop of water upon a hollow glaſs ſlip or ſlider of the microſcope, the fleſhy fibres may be ſeen to diſtend and contract themſelves in a moſt ſurpriſing manner, and to continue ſo for the ſpace of three or four minutes. The eggs alſo after diſſection may be applied to the ſaid glaſs, and eaſily examined by the microſcope, or on dipping the point of a very fine ſewing needle (it being firſt fixed in a wooden handle) into ſome turpentine, and applying that to the eggs, they will be glued thereto. The needle itſelf muſt be held between the nippers, and by its handle may be turned round at pleaſure.

It is very wonderful how ſo ſmall a creature as ſome of thoſe newly hatched maggots, that are found in the ends of blighted leaves, can be able to convolve the ſtubborn leaf, and then bind it with the thread or web it weaves from its own body, alſo to line the inſide of it with the ſame, and ſtop the two ends thereof to prevent its own falling out.

In the bodies of many caterpillars, and other nymphs of inſects, are frequently found generated great numbers of ſmall flies, whoſe parent animal had wounded the caterpillar [t], and darted its eggs into it; and ſo made it the foſter mother of its young.

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[t] Phy. Theo. p. 390.

Some inſects lay up their eggs in cluſters, as in holes of fleſh, and ſuch places, where it is neceſſary they ſhould be crowded together, which without doubt contributes towards the hatching [u].

Other inſects obſerve great order in the diſpoſition of their eggs, which may be found upon the poſts and ſides of windows, very neatly laid, being round and reſembling ſmall pearl, which eggs produce a ſmall hairy caterpillar [x]. The white butterfly alſo lays its eggs on cabbage-leaves, and always glues one certain end of them to the leaf. If theſe eggs be applied to the microſcope, you will find them curiouſly furrowed and handſomely adorned.

The peaſe ichneumon fly [y] is very ſmall, its wings large, reaching beyond the podex; antennæ long, alvus ſhort, ſhaped like an heart, with the point towards the anus; it walks and flies but ſlowly. No tail appears, but they have one concealed under the belly.

Ichneumon properly ſignifies the Egyptian rat [z], which has its name from its hunting or tracing out the eggs of crocodiles and aſps: a like obſervation made by ſome of the ancients on certain inſects of the waſp-kind, occaſioned the application of that name to waſps, as well as the Egyptian rat; there is but one paſſage in all antiquity concerning theſe waſps, viz. in Ariſtot. de Hiſt. Anim. Lib. 5. c. 20. which Pliny, Lib. 11. c. 21. hath rendered thus, "Veſpæ Ichneumones vocantur (ſunt autem minores quam aliæ) unum genus ex aranes perimunt, phalangium appellatum, & in nidos ſuos ferunt, deinde illinunt, & ex iis, incubando, ſuum genus procreant;" that is, the waſp, called ichneumons, and which are ſmaller than other waſps, kill a ſpecies of ſpiders, called phalangium,

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[u] Phy. Theo. p. 393. [x] Phy. Theo. p. 393. [y] Phy. Theo. p. 387. [z] Phil. Tranſ. No. 77.

langium, and carry them to their neſts, after which they beſmear them, and by incubation produce their own ſpecies out of them.

There is alſo a certain black and curious fly, which proceeds from the gouty excreſcencies of the briar ſtalk [a], with red legs. Black, ſmooth jointed antennæ, large thorax, and belly in the ſhape of an heart. It leaps like a flea.

The excreſcencies of the roots of cabbages, turneps, and divers other plants, have always a maggot in them, not yet ſufficiently obſerved.

Caterpillars, and divers others inſects, can emit threads or webs for their uſe. In this their nymph ſtate, they ſecure themſelves from falling, by letting themſelves down from the boughs of trees, and other high places, with one of theſe threads, and ſecure themſelves in their aurelia ſtate, in caſes of their own weaving.

Some of the fly tribe are alſo endowed with this textrine art, of theſe one ſort ſpins a long milk white ſilken web as big as the top of one's finger, woven round bent ſtalks of ribwort, &c. in meadows. The other is a lump of many yellow ſilken caſes ſticking confuſedly together on poſts, under coleworts, &c. theſe webs contain in them ſmall whitiſh maggots, which turn to a ſmall black ichneumon fly, with long capillary antennæ, tan-colour'd legs, long wings, reaching beyond their body with a black ſpot near the middle, the alvus like an heart, and in ſome a ſmall ſetaceous tail. Some of theſe flies are of a beautiful ſhining green colour. The flies coming from theſe two productions are nearly alike.

Many of the ichneumon waſps [b] are remarkable for the nidification and proviſion of their young. Thoſe which commonly have golden and black rings round their alvi, line the cells they perſorate in the earth, lay their eggs therein, and then carry into them maggots from the leaves of trees, and ſeal them up cloſe and neatly; theſe waſps have their jaws not only very ſtrong, but nicely ſized, curved, and ſet for gnawing, and ſcraping. Thoſe little holes they perforate in the earth and wood, as well as the ſeveral parts of the waſp itſelf, are a pleaſant object for the microſcope.

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[a] Phy. Theo. p. 250. [b] Ibid. p. 228.

The bearers of fruit-trees are full of aſperities, and not ſo ſmooth on their bark as the other parts of the tree are. If after harveſt, and any time in winter, you view theſe bearers in the microſcope, their cavities will be found to be full of eggs, of an oblong figure, and citron colour, eſpecially in thoſe years wherein the caterpillars [c] have been numerous. Out of theſe they are hatched in the ſpring. The ſeaſons which uſually deſtroy them, are ſuch as come in with early heats, before the coming out of the buds and bloſſoms, and on which a nipping froſty air enſues, which ſoon kills them.

Of oak cones.

THESE cones are, to appearance, perfectly like gems, only bigger, being nothing elſe than theſe increaſed in bigneſs, inſtead of length. The cauſe of this obſtruction in the vegetation is this; into the very heart of the young tender gem or bud, (which begins to be turgid in June, and to ſhoot forwards the latter end of that month, and the beginning of the next) into this bud the parent inſect thruſts one or more eggs, and perhaps not without ſome venomous [d] ichon therewith; this egg ſoon becomes a maggot, and eats itſelf a little cell in the very heart or pith of the gem, which is the rudiment of the branch, together with its leaves and fruit. The branch being thus deſtroyed, or at leaſt its vegetation obſtructed, the ſap that was to nouriſh it is diverted to the remaining parts of the bud, which are only the ſcaly integuments, by this means growing large and flouriſhing, becomes a covering to the inſect caſe, as before they were to the tender branch and its appendage.

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[c] Phil. Tranſ. No. 237.

[d] Phy. Theo. p. 397.

The caſe lying within this cone, is at firſt but ſmall, as the maggot included in it is, but by degrees, as the maggot increaſeth, it alſo grows bigger, to the ſize of a ſmall pea, long and round, in the ſhape of a long acron.

The inſect produced from the cones, hath four membraneous wings, reaching a little beyond the belly, articulated horns, large thorax, belly ſhort and conical, legs partly whitiſh, partly black, of a beautiful ſhining green, in ſome tending to a dark copper colour.

The Aleppo galls, wherewith we make ink, are no other than caſes in which inſects breed, which when they come to maturity, gnaw their way out of them, which occaſions thoſe little holes obſervable in them [e].

Of this ſort alſo are the little ſmooth caſes, about the ſize of large pepper corns, which grow cloſe to the ribs, under oaken leaves, at firſt of a bluſhing red, afterwards growing brown, hollow within, but an hard thin ſhell without, in which commonly lies a rough white maggot, afterwards transformed into a black ichneumon fly, that eats a little hole in the ſide of the gall, and ſo gets out.

Some of theſe balls are tender, as thoſe of a yellowiſh green colour with a reddiſh caſt, about the ſize of a ſmall muſket bullet, growing cloſe to the ribs, under oaken leaves, their ſkin ſmooth with frequent riſings therein; inwardly they are very ſoft and ſpongy; and in the very center is a caſe with a white maggot therein, which becomes an ichneumon fly [f]. This gall is remarkable for the fly lying therein all the winter in its infantile ſtate, and comes not to its maturity till the following ſpring. In autumn and winter thoſe balls fall down with their leaves to the ground, in which the incloſed inſect is fenced againſt the winter froſts, partly by other leaves falling pretty thick upon them, and eſpecially by parenchymous ſpongy walls, afforded by the galls themſelves.

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[e] See Phil. Tranſ. No. 245.

From the large oak balls, called oak apples, which grow in the place of the buds, out of theſe galls come another ſpecies of black flies.

The gouty excreſcencies in the body, and branches of the black-berry buſh, produce a ſmall ſhining black ichneumon fly, about a tenth of an inch long, with red jointed horns, four wings, red legs, and a ſhort belly. They hop like fleas.

All theſe inſects afford an entertaining and agreeable variety when viewed through a microſcope.

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[f] Phy. Theo. p. 400.

Of an inſect found upon the leaves of ſpices and in woods of ſeveral kinds.

MR. Leeuwenhoek diſcovered upon the leaves of ſome white nutmegs, an animalcula or minute worm, which appeared to the naked eye of the ſize of fig. 108. but is repreſented in fig. 109. as it appeared when placed before the microſcope. Its body was jointed in ſeveral places, and thickly ſet with hairs; it had ſix ſhort feet, which end with a ſhining nail, toothed like a ſaw, as at A, B, C, D; the hinder part of its body was very full of blood veſſels, as appears at E, F, G, H. At I K are two ſhining horns jointed and beſet with hairs. At L are repreſented its forceps, with which the worm eats its way into leaves or wood, &c. M N ſhew the two leſſer horns which adorn the head of the worm. This worm after ſome little time was changed into a flying inſect, as exhibited in fig. 110. whereof L M, B N, are its two horns, which conſiſted of divers joints and hairs, B L its eyes furniſhed with a number of little lenſes, as the eye of the drone fly before deſcribed. It had alſo ſix feet armed with talons, as before ſhewn: theſe legs had ſeveral joints, and were covered with briſtles or thorns; two of theſe feet and nails are ſhewn by the letters C O, D P. D E, and K I repreſents the two caſes or ſhields under which the wings are folded. Theſe caſes are moſt curiouſly adorned with ſtrait rows of rings throughout their whole length. The hinder part of its body is jointed as it were with hollow notches, much after the ſame manner as the worm from which it was produced. If the wing be conſidered, it will be found to conſiſt of ſeveral ſmall veſſels or nerves that aſſiſt in the expanſion thereof. The exquiſite neatneſs with which this minute wing was folded under the ſhields, is ſurprizingly beautiful, as appears between G H. With what wonderful nerves muſt theſe minute wings be ſtrengthned, that can enable this inſect ſo readily to fold up the extremity of this filmy membrane in ſo neat a manner, and to expand it again, as it were inſtantaneouſly, whenever it is inclined to fly? That the curious folding of theſe ſort of wings might be comprehended, Mr. Leeuwenhoek took off one of the ſhelly caſes and placed the wing before the microſcope, which appeared as in fig. 111. Q S T V W X Y repreſent the wing as it lay covered under its ſhield. It was broadeſt about V; the ſecond wing, which I ſuppoſe to be its ballance or poize, is ſhewn at S T. The extremity W X Y, ſhews thoſe neat foldings before ſpoken of, which, together with the ſtrength of the nerves, diſcover the Almighty's wiſdom in their contrivance.

I have found theſe inſect flies in ſummer-time flying about my workſhop, and have obſerved them to anſwer all the above deſcription. They are ſo ſmall, that I have applied them to the microſcope in the ivory ſliders, but they are better ſeen when applied in the nippers.

There is likewiſe a ſmall ſcarab in the very tips of elm-leaves [s]. In the ſummer many of theſe leaves may be obſerved to be dry and withered, and alſo turgid, in which lies a dirty, whitiſh, rough maggot, from which proceeds a beetle of the ſmalleſt kind, of a weeſel-colour; it leaps like a graſhopper, although its legs are but ſhort, black eyes, vaginæ thin, and prettily furrowed, with ſeveral cavities, ſmall dubbed antennæ, and a long proboſcis.

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[s] Phy. Theo. p. 252.

The ſame, or one much like this is found on the tips of oak and holly leaves.

The horſe-fly is alſo a curious object; its eye is in the form of other flies, but is as it were indented all over with a pure emerald green, its body like ſilver in froſt-work [h], fringed all over with white ſilk. If the head of this fly be cut off juſt at the ſetting on of the neck, a pulſing particle may be ſeen beating through the ſkin for half an hour together.

The trunk or proboſcis of a butterfly, which lies wound up like an helix or ſpiral ſpring, gradually growing ſlender as at fig. 113, ſupplies the office both of mouth and tongue, it may with a pin be eaſily drawn out to its full length, if it be cut off and laid upon the object carrying glaſs, and ſo applied to the microſcope you will ſee it wind and coil [i] itſelf up, and then to open itſelf again for a long time together, nature having made it of a ſufficient length, that when extended it may reach into the hollows of flowers, and from thence extract their dews and juices. It conſiſts of two tubes near its extremity, as repreſented at A C, fig. 113. the cavities of which unite at D, and from thence to the throat of the butterfly form but one channel [k]. Theſe tubular extremities are unfolded in the manner expreſſed at B T N, fig. 114. in order to extract the dews, &c. from flowers; after which it is immediately drawn back and coiled up into an helix. M M, fig. 115. repreſents one of the extreme parts viewed with a greater magnifier, and delineated exactly in the manner as it is applied to leaves and flowers. Whence it appears, that it is not the extreme end of the proboſcis, which extracts the dews and juices;

but

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[h] Power's Micro. Obſ. p. 7. [i] Ibid. p. 8. [k] Micro. de Bonan. Pars 2. p. 48.

but ſeveral nipples D E F, that are applied to the leaf A C, at the points i i i.

In all graſhoppers there is a green film or plate (like a croſlet) which covers the neck and ſhoulders; if you raiſe it up with a pin you may ſee their heart beat [l] for a long time together. The graſhopper is beſt held between the nippers, and ſo applied to the magnifier.

There is a pretty object, which is a white oblong inſect that ſticks to the back-ſide of roſe-tree leaves [m] in Auguſt, of a perfect white, it changes into a ſmall yellow locuſt, with two white wings longer than its body, and two pointers in the ſnout like a pair of cloſed compaſſes, and may be plainly ſeen when the fly is laid upon its back.

Upon the backſide of the leaves of gooſeberries, ſweet briar, and golden mouſe-ear in April and the beginning of May, is a greeniſh graſhopper or locuſt [n], which is a pleaſant object; when placed before the microſcope it hath two horns and four legs, and two curious black eyes.

On ſycamore leaves there is a yellow inſect [o], which at firſt hath no wings, but ſix legs and two horns which are ſlit; it runs nimbly, the eyes are globular and red, pearled and prominent; near the ſhoulders are two ſtumps, whence two long wings come forth, when it changes into a fly or locuſt, it conſiſts of annulary circles, and is hairy towards the tail.

There is to be found a ſmall long black inſect, creeping and leaping amongſt pinks, gilly-flowers, roſe-leaves, &c. with a waſp-like body, with ſix or ſeven annulary diviſions; two curious horns ariſing from a black knobbed root, two fine long yellow wings, black eyes, and ſix black legs, they are killed with the leaſt touch imaginable;

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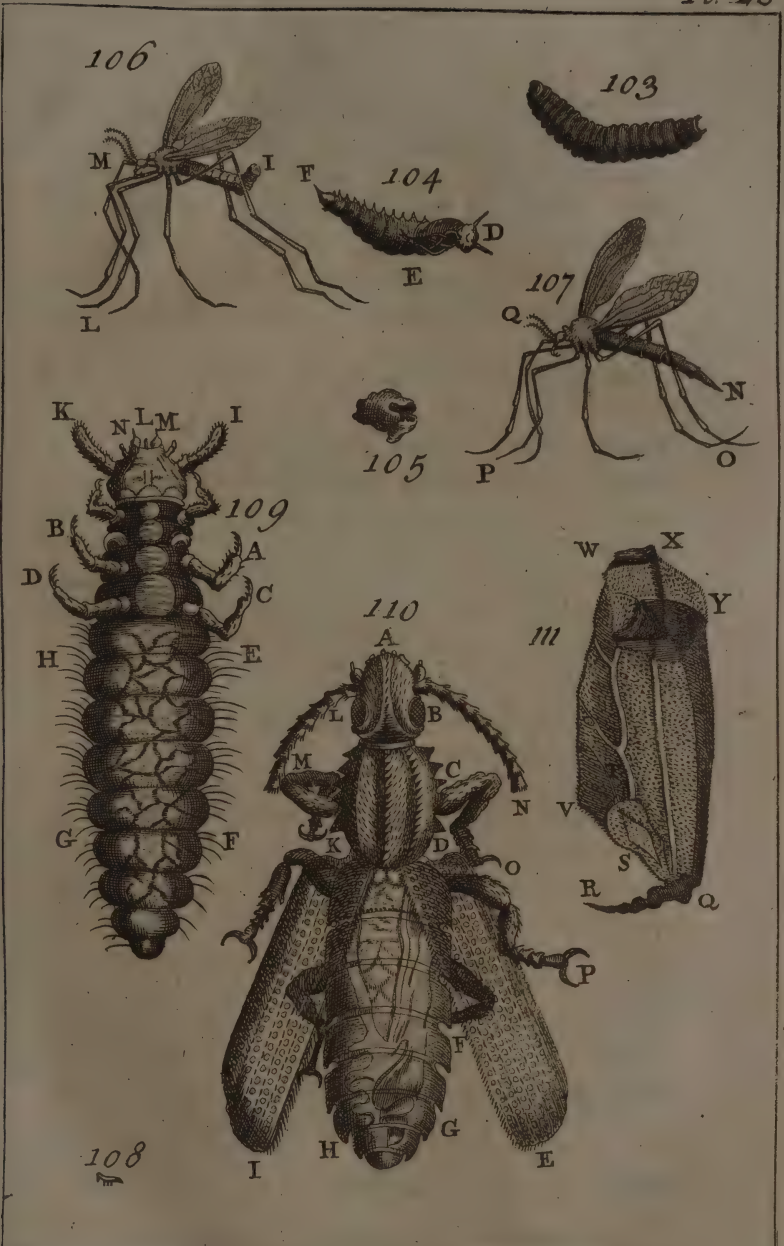
[l] Power's Micro. p. 24. [m] Ibid. p. 27. [n] Ibid. p. 26.

[o] Ibid. Micro. Obſ. p. 32.

Pl. 28



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Bowles Sc.

able; their ſize is leſs than that of a louſe [p]: they may be taken up with the point of a pin dipped in ſpittle, and by that means placed, or as it were glewed to a very ſmall bit of card, which may be applied to the microſcope in the nippers. And ſtronger inſects may be ſtuck to a larger piece of card with a touch of turpentine, and applied to the magnifier in the nippers as before.

On the froth, which hangs on the leaves of lavender, horſe-mint, roſemary, &c. [q] (by ſome called cuckow-ſpit) is always found a little inſect of a golden colour; it hath ſix legs, with two black claws at the end of each, which it can open and ſhut at pleaſure; its eyes are pearled and of a duſky red, a long reddiſh proboſcis is ſituated between its fore legs; its tail had ſeveral annular diviſions that ended in a ſtump, which it could at pleaſure thruſt out or draw back; it firſt creeps, then leaps, and at laſt flies.

The cow-lady, lady-bird, or ſpotted ſcarabee, is a very nimble animal; cut off its head, and erect it perpendicularly upon the neck (which may be faſtened to a bit of ſoft wax firſt ſtuck upon the point, or by a drop of gum-water upon a piece of card, which may be held in the nippers, and ſo applied to the microſcope) and you will ſee two ſmall black eyes ſet upon three white plates like poliſhed ivory, two ſmall ones on one ſide, and a large one on the other; pull off both the cruſtaceous and filmy wings, which are a fence to a thin tender black ſkin, under which the pulſation of the heart [r] may be ſeen to beat vigorouſly for twelve or fourteen hours, after the head and neck are ſeparated.

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[p] Power's p. 31. [q] Ibid. p. 28. [r] Ibid. p. 30.

There is a fly with grey and black ſtreaks on the ſhoulders [s], and chequered on the tail with the ſame colours; upon opening the female of this fly, which may be diſtinguiſhed by a redneſs on the extremity of the tail, you will find two bags of live white worms, long and round in ſhape, with black heads, moving both on the hand and in the unopened veſicles backwards and forwards, being diſpoſed in cells according to the length of the animal's body.

Of the cochineal fly.

THE microſcope hath diſcovered to us that cochineal, ſo valuable for its uſe in dying crimſon, ſcarlet, and purple, is an inſect bred upon the plant called prickly pear, or Indian fig [t]; and upon the leaves or twigs thereof are ſmall knobs or protuberances, which produce little worms that in time become flies, reſembling cow-ladies, or lady-birds; which, when arrived at their full growth, are taken by the inhabitants (of the iſlands of Cuba, Hiſpaniola and Jamaica, from whence it moſt commonly comes) and expoſed to the heat of the ſun to dry, and rubbed between the hands till their wings, legs, &c. fall off. Upon ſteeping ſome of the grains of cochineal twenty-four hours in water, a trunk with ſcales and legs will appear; and if their bodies be opened, many eggs of different ſizes may be alſo found.

Fig. 116. repreſents a grain of cochineal; fig. 117. another grain, as it appeared through a microſcope, in which at the extreme parts C and E F, an orifice appears, from whence the ſtring was broken off, whereby both parts of the body were joined together. The concave arches D G, &c. are not natural, but adventitious to the ſame grain, proceeding only from the drying or ſhrinking up of the great number of eggs that lie within the animalcula; for if the ſame grain was well ſoaked in water, the concave parts would become convex. Fig. 118. ſhews an egg with its membrane, as it was taken out of a grain of cochineal ſteeped in rain-water for about twenty-four hours; in which might be ſeen the young one, and its ſhell ſurrounding it. L M N, fig. 119. repreſents one of theſe unborn animalcula. Fig. 120. ſhews the body of another animalculum which was taken out of the egg-ſhell, in which not only the body was diſtinctly ſeen, but alſo the parts thereof divided into ſeveral circles, and likewiſe the two horns with the joints wherewith nature hath provided all thoſe unborn animalcula, were plainly viſible when placed before the microſcope. B H, D I, and D K, ſhew its four legs, the other two being hid from the ſight. F G repreſent the horns, at the extremity of each of which are three ſmall hairs.

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[s] Phil. Tranſ. No. 72.

[t] Phil. Tranſ. No. 292.

Of the death-watch.

THERE are two kind of inſects which make a regular clicking noiſe like the beats of a pocket watch; one of them called by Swammerdam, ſcarabeus ſonicephalus, and the other called by Mr. Derham, pediculus pulſatorius.

The firſt of them is a ſmall beetle, about five ſixtenths of an inch in length [u], of a dark brown colour, with ſpots ſomewhat lighter irregularly placed. It is repreſented of its natural ſize at fig. 121. Under its vaginæ are pellucid wings, the head large, by reaſon of a cap or helmet which covered it, only a little turned up at the ears; under this appeared its head, which was flat and thin, the eyes forward, the lips hard and ſhining, the bars of the helmet greyiſh; two antennæ proceeded from under the eyes, the head all hairy, and face thick of curled hair; on the belly was a little hair, but thinly ſet; its eyes like thoſe of a fly. Fig. 122. is a microſcopic picture of it; between the eyes the face riſes in a little ridge, which is the noſe; and juſt below it the noſtrils are covered with ſtrait pendulous hair, the lip-ſhades ſhew the more depreſſed places; under this lip are four viſible forceps, two on each ſide to lay hold on its food. They make a noiſe juſt like the beats of a pocket-watch. Mr. Derham has often cauſed one of them to beat when he pleaſed by imitating its beating, and this he kept in a little box about three weeks; and imagines, that theſe pulſations is the way theſe inſects woo each other, and invite to copulation; and that it always draws back its mouth, and beats with its forehead [x].

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[u] Phil. Tranſ. No. 245.

[x] Phil. Tranſ. No. 271.

The other death-watch is an inſect different from the foregoing, that beats only about ſeven or eight ſtrokes at a time, whereas the former will beat ſome hours together without intermiſſion, and its ſtrokes ſlower, and like the beats of a watch. It is a ſmall greyiſh animal, much reſembling a louſe; for which reaſon it is called pediculus pulſatorius. It is very nimble, but extremely ſhy when diſturbed; it will beat freely enough before you, and alſo anſwer you when you beat, if you can view it without giving it any diſturbance, or ſhaking the place whereon it lies. It is not certain whether they beat on any other thing but paper, their noiſe being heard only in or near it.

Fig. 123. repreſents the ſecond ſort of death-watch [y], as it appears to the naked eye. Fig. 124. ſhews it a little magnified; its ſhape and colour is not much unlike a louſe; it is common in moſt houſes in the warm months, but in the cold ſeaſon of the year it hides itſelf in dry obſcure places, and is ſeldom ſeen; ſome time after copulation, they lay their eggs in dry duſty places; they are much more minute than the nits of lice, of a whitiſh colour, and are hatched by the warmth of the approaching ſpring, which to them is all the ſame as an incubation: the inſect is fully hatched, and can creep about at the beginning of March, or ſooner if the weather be warm; at their firſt quitting the egg-ſhell, they are ſo exceeding ſmall, as ſcarce to be diſcerned, without the aſſiſtance of a convex glaſs: in this ſtate Mr. Derham could find no other difference between them and mites in cheeſe, when viewed with a microſcope that magnified much, but that mites had more briſtles about the breech: in this ſhape they continue ſix weeks or two months, feeding on divers things they can meet with; after which they gradually increaſe towards their more perfect ſtate, when they become like the old ones.

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[y] Phil. Tranſ. No. 291.

Mr. Derham has plainly ſhewn, that their ticking noiſe is a wooing act, and that it is commonly about July [z]; he never found them in coitu, till about a week or a fortnight after their ticking; though it is probable they copulate at that very time. He has ſeen the old death-watches feed upon dead inſects, as the young ones do, and alſo upon biſkets, tallow, &c. nay duſt itſelf, and hath obſerved them through a microſcope to ſelect ſome grains thereof, and reject others.

Of a gnat.

THE firſt obſervable in the generation of this inſect, is its vaſt ſpawn, ſome of them being one inch and half long, and one eighth of an inch broad, floating in the water, but being made faſt to ſomething to prevent its being waſhed away; in this tranſparent ſpawn the eggs are neatly depoſited, in ſome a ſingle, in others a double ſpiral line [a], running from end to end, as in fig. 125 and 126. and in ſome tranſverſly, as in fig. 127.

When the eggs are by the heat of the ſun, and warmth of the ſeaſon, hatched into ſmall maggots, theſe maggots deſcend to the bottom; and by means of ſome of the gelatine matter of the ſpawn, which they take along with them, they ſtick to ſtones, and other bodies at the bottom, and there make themſelves little caſes or cells, which they creep into, and out of at pleaſure, till they arrive at a more mature nymph ſtate, and can ſwim about here and there in queſt of food; at which time they

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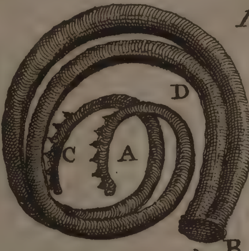
[z] Phil. Tranſ. No. 271.

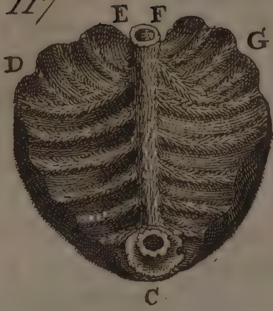
[a] Phy. Theo. p. 394.

116

113



117



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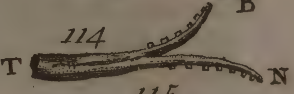

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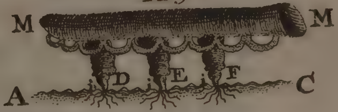

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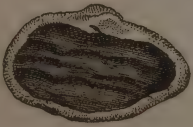

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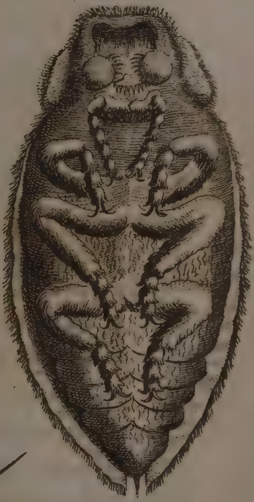

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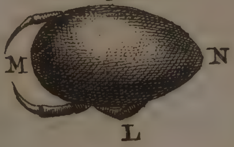
119



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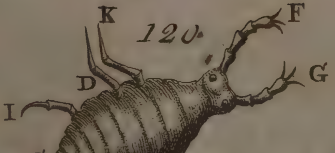

124

123

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they are a kind of red worms about half an inch long, but of the ſhape of fig. 128.

It has a very large head, in proportion to its body, which is all covered with a ſhell; ſeveral tufts of hair on ſeveral parts, two horns, a large mouth, &c. The form of the whole creature will be better perceived by a deſcription of fig. 128. the hinder part or belly conſiſts of eight ſeveral joints. From the midſt of each of which, on either ſide, iſſue out three or four ſmall briſtles. The tail was divided into two parts, very different in make; one of them A, had ſeveral tufts of hair or briſtles, with which it could ſteer itſelf as it pleaſed, and was enabled to ſwim about by curvations and flapping its body ſideways, this way and that, and keep itſelf near the ſurface of the water: the other part B appeared to be the ninth diviſion of its body, and on each ſide had many ſingle hairs. From the part C to the head, appeared a darkiſh coloured gut, through which the periſtaltic motion was very diſcernable. The cheſt D E of this creature was thick and ſhort, and ſo tranſparent, that its white heart could be ſeen to beat: its cheſt was ſtuck with ſeveral tufts or briſtles, and the head was alſo adorned with the ſame; it had two black eyes, and two ſmall horns F G.

Both the motion and reſt of this creature are ſurprizing and pleaſant. The tail ſeems much lighter than the reſt of its body; and being a little lighter than the water in which it floats, buoys it up to the top thereof, where it hangs ſuſpended with its head downwards; they lift their heads ſometimes into the air, at other times plunge them into the water, their tails all the while ſliding along its ſurface.

After having lived in this manner the time which providence has allotted them, a ſtranger change ſucceds;

they appear in form of fig. 129. and then they caſt off their whole ſkin, eyes, horns, and tails; and iſſue forth as inſects of a quite different element: the moſt beautiful and elegant plumage adorns their heads; their limbs are of the fineſt texture; their wings are curiouſly fringed and ornamented; their whole bodies are inveſted with ſcales and hair; and they are actuated by a ſurprizing agility; in ſhort, they become gnats, and ſpring into the air; and what is moſt amazing, a creature, that but a minute ſince was an inhabitant of the water, would now be drowned if it were plunged therein.

It is very probable, that many ſorts of the animalcules in fluids undergo ſome ſuch like change.

Of the tufted, bruſh-horned, or male gnat.

ITS ſurprizing and particular beauties are only to be diſcovered by the microſcope; and is exactly of the ſhape of one of thoſe which Mr. Hook obſerved to be generated out of one of the little watery inſects juſt deſcribed.

Nature has adorned it in a moſt ſurprizing manner: its head A is exceeding ſmall in proportion to its body, which conſiſts of two cluſters of pearled eyes, fig. 130. curiouſly ranged like thoſe of other flies; between which, upon two blackiſh balls, are placed two long jointed horns D, tapering towards the top; from whence iſſued out in a circular manner, multitudes of ſmall ſtiff hairs from its ſeveral joints, exactly reſembling the ſproutings of the herb horſe-tail. There are alſo two other jointed and briſtled horns or feelers D, and a proboſcis F, underneath which is the ſucker or ſting, which in ſome gnats is very long. This ſmall head, with its appurtenances,

tenances, is joined by a ſhort neck to the thorax G, which is large, and as it were caſed with a black ſhell; out of its under part proceeded ſix long ſlender legs H H, &c. much like thoſe of other flies, but longer and ſlenderer, which are not expreſſed in the figure, becauſe of their great length. From the upper part proceeds two long ſlender tranſparent wings, ſhaped ſomewhat like thoſe of a fly; underneath which, as is obſervable in many ſorts of flies, are placed two ſmall bodies, which are its ballances or poiſes. Its belly large, and extended into nine partitions, each being armed with rings of ſhells; ſix of which were ſo tranſparent, that the periſtaltic motion was plainly viſible. A ſmall clear white part at I, ſeemed to beat like the heart of a larger animal; the three laſt diviſions of the tail were covered with opake ſhells.

Of the great bellyed or female gnat.

ALTHOUGH this gnat, as repreſented in fig. 131. differs from the former in ſhape, yet this ſort alſo has been found to be generated out of the water inſect before deſcribed: its wings were larger than thoſe of the other; its belly bigger and ſhorter; its thorax not much unlike that of the other, having a ſtrong rigid back piece and breaſt plate; its head larger and neater ſhaped; the horns, that grew out of thoſe two little balls, which were between its eyes, was of a different ſhape from the tufts of the other gnat; theſe having but a few knots or joints and a few ſhort briſtles; the foremoſt horns or feelers like thoſe of the former.

In different ſpecies of gnats their wings are alſo different; ſome having a border of long feathers, others of ſhort ones, and others none at all: the rib-work of the wings is feathered in ſome and ſcaled in others, and in ſome beſet with prickles.

Mr. Hook ſuffered one of theſe gnats to pierce the ſkin of his hand, and thence to draw out its fill of blood, which made it appear very red and tranſparent, and this without any further pain, than whilſt the ſting was entering; a good argument that theſe creatures do not wound the ſkin out of revenge, but for mere neceſſity to ſatisfy their hunger.

This piercer, ſting, or ſucker, as repreſented by F G H I, fig. 132. is a caſe covered with long ſcales and hairs; it lies concealed under the gnat's throat, when not made uſe of; but when it is, the ſide G H opens, and four darts are thruſt out therefrom occaſionally; one whereof H K (minute as it is) ſerves for a caſe to the other three; the ſides of which towards the point K are barbed or indented. F I ſhew that part of the ſting where it was cut off from the gnat's throat.

Fig. 133. repreſents part of the ſecond ſheath, whoſe ſides near the top are barbed, but not here expreſſed. This alſo opens ſide-ways for a paſſage to the three included ſtings.

Fig. 134. ſhews all the parts of the ſtings wherein two of the interior ones might be ſeen barbed and indented towards the point; their fineneſs is almoſt inexpreſſible, they have three ſides, as repreſented in fig. 135, whoſe edges ſeemed to join alternately (which when ſo united reſemble a three edged ſword, or dagger.) Fig. 136, ſhews another part of one of thoſe interior ſtings, which is remarkably ſmall and ſomewhat curved. Its top on the plain ſide is ſhewn at fig. 137. which top is repreſented in another poſition, fig. 138. A, and in the poſition of B its hooks might be ſeen. When theſe darts

are thruſt into the fleſh of animals either ſucceſſively or in conjunction, the blood and humours of the adjacent parts muſt flow to, and cauſe a tumour about the wound, whoſe little orifice being cloſed up by the compreſſion of the external air can afford them no outlet. When a gnat finds any tender juicy fruits, or liquors, ſhe ſucks up what ſhe likes through the outer caſe, without uſing the darts at all; but if it is fleſh, that reſiſts her efforts, ſhe ſtings very ſeverely, then ſheaths her weapons in their ſcabbard, and through them ſucks up the juices ſhe finds therein. Upon diſſection many curious things may be diſcovered, viz. numberleſs animalcula in the ſemen of the male [b], and in the female a ſurprizing quantity of eggs.

There is a kind of gnat which lays its eggs frequently in dead beer, &c. and ſome time after this the maggots are ſo numerous, that the whole liquor ſeems to be alive, being full of maggots; the larger ſort being the offspring of this gnat [c]; and the ſmaller that of a ſmall dark coloured fly, tending to a reddiſh colour, frequent in cellars and ſuch obſcure places; they turn to aurelia, and the larger ſort from that to a gnat of a brown colour. The chief difference between the male and the female is, that the male is leaſt, hath a ſlenderer belly, and its podex not ſo ſharp as the female's is. This gnat hath no ſpear in its mouth.

Theſe inſects may be applied to the univerſal microſcope, by pinching them between the nippers, or ſticking them upon the point; their ſtings when cut off may be beſt examined upon a glaſs ſlider when placed on the ſtage.

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[b] Arc. Nat. Tom. iv. p. 22.

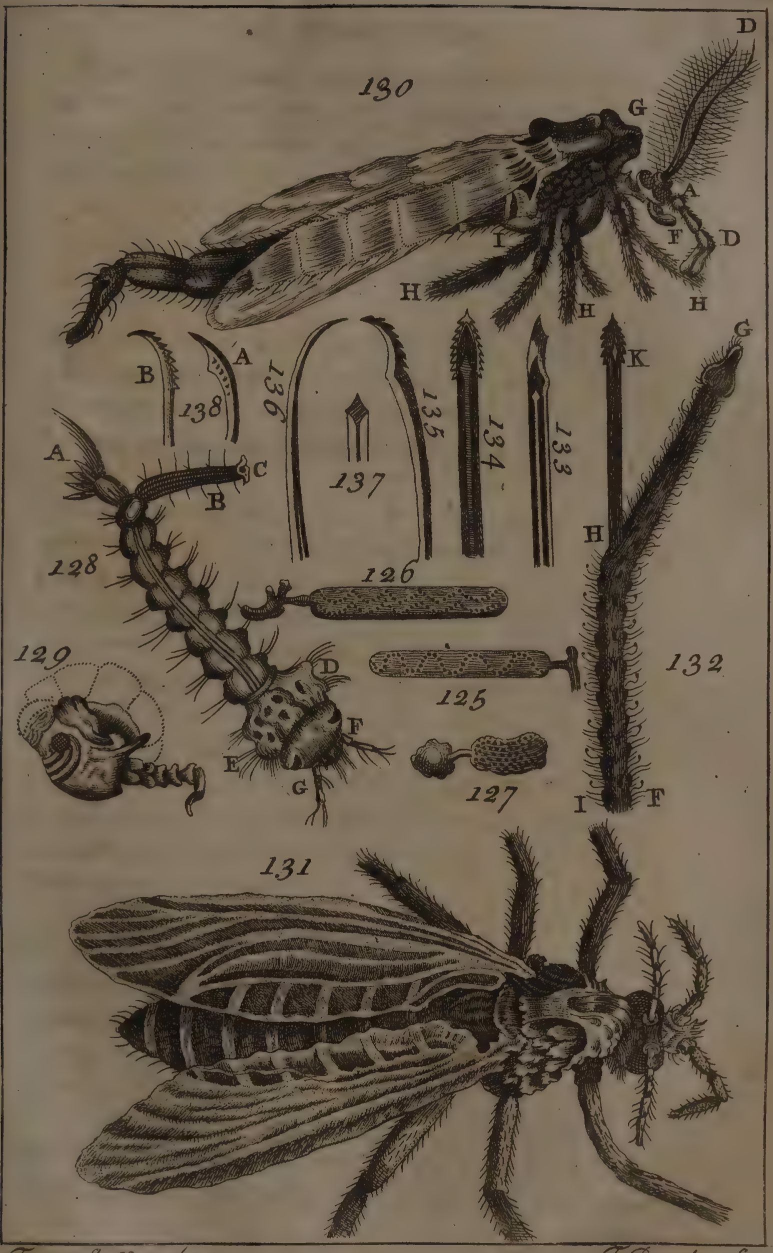
[c] Phy. Theo. p. 386.

Of

Of the white feathered winged moth.

IT appears to the naked eye to be a ſmall milk-white fly with four wings, the two foremoſt ſomewhat longer than the hindermoſt, and theſe about half an inch in length; each of theſe wings conſiſts of two feathers, as repreſented in fig. 839. very curiouſly tufted or haired on each ſide, with exceeding white but minute hairs; its whole body, legs, horns, and ſtalks of the wings were covered over with various kinds of white feathers, which rub off between the fingers when touched. Underneath theſe feathers this curious inſect was covered all over with a cruſted ſhell. It had alſo different feathers, that covered ſeveral parts of its body; the tufts or hairs of its wings, when viewed in the microſcope, appear as repreſented in the fig. by D. The feathers which covered a part of its body, like A, conſiſting of a ſtalk and a ſeeming tuftedneſs on each ſide; others which covered ſome parts of its body, and the ſtalk of its wings much like fig. B, thoſe which covered its horns and the ſmaller parts of its legs, in the ſhape of fig. C. Mr. Hook obſerved, that the ſmooth winged inſects have the ſtrongeſt muſcles; and even this very inſect had a very ſmall body, if compared to the length and number of his wings; which therefore as he moved them very ſlowly, conſequently moved them as weakly; which laſt property is in ſome meaſure obſervable in the larger kind of flying creatures, as birds, &c. So that by the aſſiſtance of the microſcope we find, that the wiſdom and providence of the all-wiſe Creator, is no leſs ſhewn in thoſe deſpicable creatures, flies, moths, &c. than in the larger parts of the creation.

Pl. 30.



Front.g Pag. 89 T. Bowles ſc.

wooden beam, or other body to their mind, into which they gnaw holes with their ſharp fangs, capable of concealing them; and there envelope themſelves in a covering of their own ſpinning; where they ſoon become metamorphoſed into dark coloured aurelias [d], and continue ſo all the winter unactive and harmleſs: but about April or May, as the weather grows warm, they are transformed into moths of the kind before deſcribed. Then are they to be ſeen in great numbers taking little flights, or creeping along the walls. In the fly-ſtate they eat nothing, therefore are not miſchievous, but ſoon copulate and lay eggs, not larger than a grain of ſand, in ſhape like thoſe of an hen, each female ſixty or ſeventy, which by means of a tube at the end of her tail, repreſented by fig. 142. as it appears in the microſcope, ſhe thruſts or inſinuates into the little wrinkles, hollows, or crevices of the corn; where in about ſixteen days they hatch, and then the plague begins: for the minute worms or maggots immediately perforate the grain where they are hatched upon, eat out the very heart of it, and with their webs cement other grains thereto, which they likewiſe ſcoop out and devour, leaving nothing but huſk and duſt, and ſuch a quantity of their dung, as ſhews them to be more voracious inſects than the weevil, hereafter to be deſcribed.

Theſe worms or maggots may be kept all the winter in glaſs tubes, that are ſtopped at each end with a cork and wax, having firſt a bit of a very ſmall glaſs capillary tube, put through the cork to give them air. In this manner Mr. Leeuwenhoek confined ſome of theſe moths with a few grains of corn, and ſaw them lay their eggs in the crevices of the corn; alſo in this manner he obſerved all the above particulars.

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[d] Leeuwenhoek's Exp. & Contemp. Epiſt. 71.

Theſe little moths are covered all over with an infinite number of little feathers joined to their wings, and other parts of their bodies by a quill, as thoſe of birds are, but ſo extremely different in ſhape, that ſcarce two of them can be found alike. Fig. 144. ſhews three of the larger ſort, ſomewhat blackiſh towards the top, but tranſparent near the ſtalk. Fig. 143. ſhews three others perfectly tranſparent, ten of the ſmaller ſort are exhibited in fig. 145. but all of them of a different ſhape. Theſe feathers which compoſe the borders of the wings, but eſpecially thoſe which grew upon that part of the wing which was near the body of the moth, were alſo of different faſhions, and much longer than the former. Five of this ſort are ſhewn in fig. 146.

The methods of deſtroying this vermin are, when they forſake their food, and aſcend the walls, or when they appear in the moth ſtate; at both theſe times they may be cruſhed to death by clapping ſacks upon them: but they may ſtill be more effectually deſtroyed by cloſing up all the doors and windows, and filling the corn-chambers with the fumes of brimſtone [e], by leaving it burning on a pan of charcoal, without giving it any vent for twenty-four hours: however, after that great care muſt be taken to open them all again for ſome hours, that the fumes may be entirely gone before any body enters.

N. B. The fumes of the ſulphur are not hurtful to the grain.

The nymph of the cloaths moth, called by Mr. Hook, the ſilver coloured book-worm, is a curious object. It is a ſmall ſilver coloured ſhining worm, and is often found ſcudding among books and papers. Fig. 147. repreſents this worm as it appears in the microſcope, having

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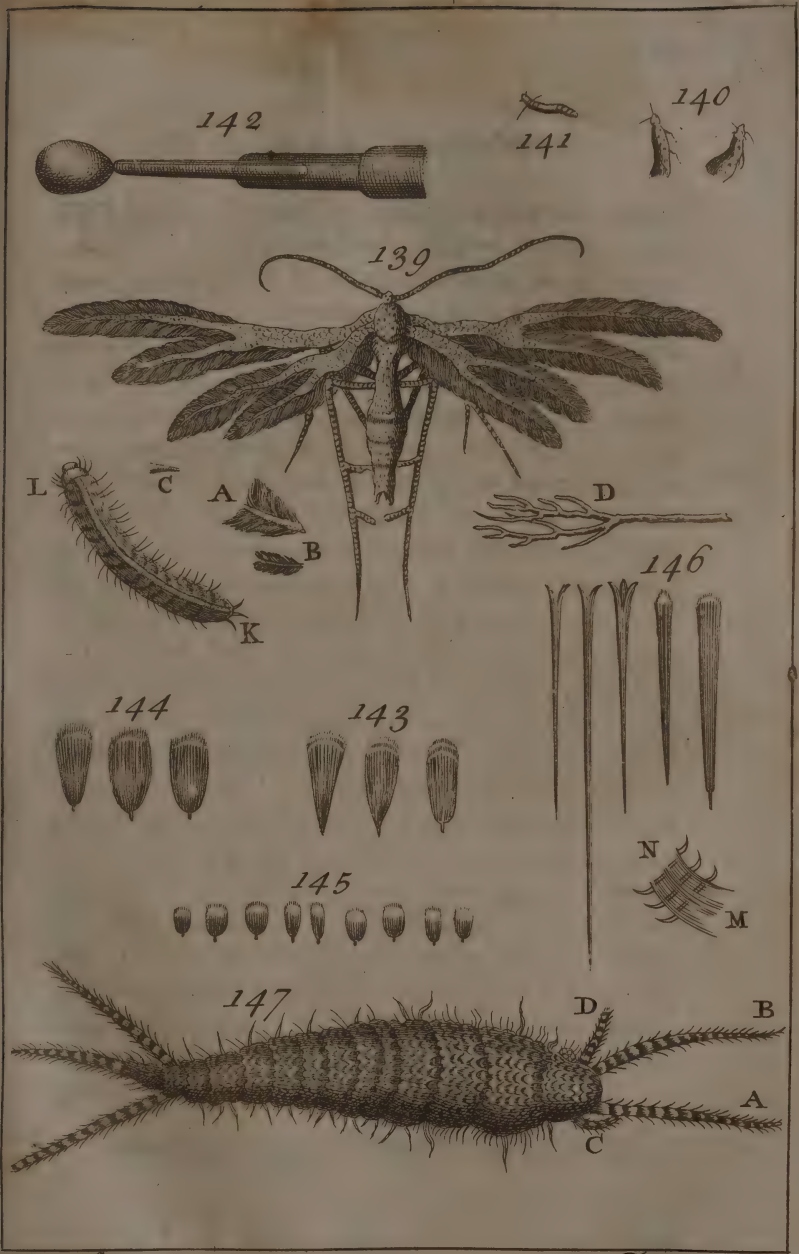
[e] Leeuwenhoek's Exp. & Contemp. Epiſt. 71. p. 246.

having a conical body, divided into fourteen ſhelly partitions, each of which are covered with a multiplicity of thin tranſparent ſcales, which from their ſeveral reflecting ſurfaces, make the whole animal appear of a perfect pearl colour: the ſmall blunt head of this inſect is furniſhed on either ſide with a cluſter of eyes, (but fewer in number than thoſe of other inſects) each of which was beſet with a row of ſmall briſtles. It has two long horns A B, ſtrait and tapering towards the top, curiouſly ringed and briſtled, with a girdle of ſmaller hairs at each ring, and ſeveral larger briſtles here and there diſperſed among them, alſo two ſhorter horns or feelers C D, knotted and fringed like the former, but without briſtles; its hinder part terminated in three tails, reſembling the two long horns in every particular. It had ſix legs ſcaled and haired, which could not be repreſented in this poſition. Theſe little nimble animals are beſt applied to the microſcope, upon a ſingle piece of talc, or a thin ſlip of glaſs, pinched in the nippers, having firſt ſtuck them thereto with a ſlight touch of turpentine, or a drop of gum water.

Pl 31



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T. Bowles ſc.

Of the weevil, or corn-beetle.

THIS little inſect is ſomewhat bigger than a large louſe of the ſcarab kind. It does much harm to many ſorts of grain, by eating into them, and devouring all their ſubſtance. As many people are unacquainted with the weevil, I have exhibited a picture of it, in fig. 148. of the full ſize it appears of to the naked eye. It has two jointed horns, which are repreſented as they appear when viewed through a microſcope, at E, H, G, fig. 149. Its trunk at E D B, and its forceps or ſharp teeth D, with which it gnaws its entrance into the heart of the grain, either for food, or to depoſite its eggs. Between the forceps at D, appears a kind of ſucker, with which it licks up the flower or duſt of the grain.

If ſome of them are kept in glaſs tubes, prepared as before deſcribed, that the air may have a free paſſage into them, with a few grains of wheat, their copulation may be diſcovered, and alſo their manner of generation, which is thus performed [f]. The female perforates a grain of wheat, and therein depoſites a ſingle oblong egg or two at the moſt, and this ſhe does to five or ſix grains every day, for ſeveral days together; theſe eggs, which are not above the ſize of a grain of ſand, in about ſeven days produce an odd ſort of white maggot, which wriggles its body very much, but is ſcarce able to move from place to place; the maggot turns into an aurelia, which in about fourteen days comes out a perfect weevil.

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[f] Leeuwenhoek's Exp. of 6 Ang. to the Royal Society.

Of the flea.

THESE little creatures are a ſurprizing object, when examined by the microſcope; they are male and female, and undergo the ſame changes as the ſilk-worms do. They depoſite their eggs at the roots of the hair [g] of dogs, cats, and other animals, and by a glutinous matter ſtick them faſt thereto; one of theſe eggs is repreſented magnified in fig. 150, and at 151. the ſame egg broken by the worm, fig. 152. hatched therein. This worm [h] contains the flea, and is compoſed of ſeveral annular diviſions, thinly ſet with long hairs, having at its head two extremely minute horns at A; theſe worms feed upon the juices of the body whereunto they cloſely adhere. They are very nimble, but if diſturbed, roll themſelves ſuddenly into a round figure, and continue motionleſs for ſome time; after which they open themſelves by degrees, and crawl ſwiftly away. They endeavour to conceal themſelves when their change draws nigh, eat nothing, lie quiet, and appear dying, but if placed before the microſcope, will be found with the web in their mouths, weaving a covering round them; the inſide of which is perfectly white, but its outſide as it were ſoiled with dirt. In this bag they put on the chryſalis, which is repreſented at fig. 153. diveſted of its vermicular ſkin. About two or three days before they break forth from this confinement, their colour darkens, and as ſoon as they iſſue from the bag, are perfect fleas, and able to leap away. A microſcopic picture of a perfect flea is repreſented by fig. 158.

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[g] Phil. Tranſ. No. 249.

[h] Arc. Nat. Tom. iv. Epiſt. 76.

It is all over adorned with a curiouſly poliſhed coat of armour, or hard ſhelly ſcales, neatly jointed and folded over each other, and beſet with long ſpikes, almoſt like porcupine's quills: its neck bears ſome reſemblance to a lobſter's [i] tail: its head is adorned on either ſide with a beautiful quick and round black eye; behind each of which appears a ſmall cavity, in which moves a thin film, ſet with ſmall tranſparent hairs, which may probably be its ear [k]. From the fore part of its head, proceeds a pair of little jointed hairy horns, or ſeelers A B. Between theſe and its two fore legs C D, is ſituated its piercer or ſucker, that included a pair of darts, which after the piercer has made its entrance, are probably thruſt farther into the fleſh, to make the blood flow from the adjacent parts, that it may be ſucked up; and ſeem to occaſion that round red ſpot, with a hole in the center of it, which we commonly call a flea-bite. This piercer, its ſheath opening ſide ways, and the two lancets within it, are very difficult to be ſeen [l], unleſs the two fore legs, between which they are uſually folded in, and concealed from view, are cut off cloſe to the head; for a flea rarely puts out its piercer, except at the time of feeding, but on the contrary keeps it cloſely folded inwards; one way therefore of coming at it, is by cutting off the head firſt, and then the fore legs; ſince in the agonies of death, it may eaſily be managed and brought before the microſcope. But this requires a great deal of patience and dexterity. Therefore another more likely way to ſucceed in this experiment, is, when the flea is juſt dead, to take hold of its back with a pair of nippers, and then apply it to the ſixth magnifier; and having a ſmall ſewing needle ready fixed in a handle, I have been able to preſs the

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[i] Power's Micro. Obſ. p. 2.

[k] Hook's Micro. p. 210.

[l] Arc. Nat. Tom. iv. p. 332. Phil. Tranſ. No. 249.

the horns forward with the point of the needle, and its two fore legs nearer to the body; and this whilſt I was looking through the microſcope; by which means I could then exactly ſee where to place the point of the needle, ſo as to raiſe up the piercer in the ſituation D E, as expreſſed in fig. 154. which repreſents a part of the flea's head; and at the ſame time I have opened the piercer, and ſeparated its two lancets, and this without cutting off any part of the flea, fig. 154. A B C are the two horns, and D E are the two ſides of the piercer, which are partly hollow, that they may the better include the lancet, or dart, which in this figure appears to be but one, but if carefully ſeparated, will be found to conſiſt of two parts, as in the next figure 155; whereof G H and G I repreſent as before the two parts of the piercer beſet with ſeveral hairs, and G H ſhews the two darts, but not ſeparated. At fig. 156. they may be ſeen aſunder, whereof L O, L N, are the two hairy parts of the piercer before ſpoken of, and L M, O L P the darts; in L M may be ſeen the cavity, which includes or receives the other dart L P; when they are ſhut up between the fleas fore legs, all the four make but one proboſcis.

Beſides theſe two legs before ſpoken of, which adhere to the head of this little creature, it has four others, which are joined to its breaſt; theſe ſix legs the flea clitches up altogether; and when he leaps, ſprings them all out at the ſame inſtant, and thereby exerts his whole ſtrength at once, which carries him to a ſurprizing diſtance, above hundred times its own length. Its legs have ſeveral hairy joints, which terminate in long hooked claws; as in fig. 158.

If the eggs of fleas be conſtantly warm in one's boſom (it has been obſerved that) in the midſt of ſummer, they hatch in four days; then feed the maggots with dead flies, which they greedily ſuck. In eleven days they come to the full perfection of the reptile ſtate, when the maggot ſpins its bag, and in four days more changes into a chryſalis; after lying in which condition nine days, it becomes a perfect flea. It is then immediately capable of coition, and in three or four days lays eggs; ſo that in [m] twenty-eight days, a flea may come from its egg, and propagate its kind; and their vaſt increaſe will not ſeem ſo great a wonder if we conſider, that from March to December there may be ſeven or eight generations of them; after having laid their eggs they ſoon die, as all creatures do that undergo ſuch like changes.

If you keep fleas in ſuch a glaſs tube, as is before deſcribed, ſo as to admit freſh air, their ſeveral actions may be obſerved, and particularly their way of coupling, which is performed tail to tail. The female (which is much the larger) ſtanding over the male: they will alſo be ſeen to lay their eggs, not all at once, but ten or twelve in a day for ſeveral days ſucceſſively; which eggs hatch in the ſame order.

A diſſection of the flea may be effected in water, the [n] ſtomach and bowels, with their periſtaltic motion, may plainly be diſtinguiſhed, and alſo the teſtes and penis, together with veins and arteries, minute beyond conception. Mr. Leeuwenhoek affirms, that he has likewiſe diſcovered innumerable animalcules, ſhaped like ſerpents, in the ſemen maſculinum of a flea.

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[m] Arc. Nat. Tom. iv. p. 325.

[n] Ibid. p. 335.

Of the louſe.

THE tranſparency of its ſkin enables us by the help of the microſcope, to diſcover the motion of the muſcles [o], (which unite in an oblong dark ſpot in the middle of its breaſt) as the louſe moves its legs; and alſo in the head, when the horns are moved, and in the ſeveral articulations of its legs. The periſtaltic motion of the inteſtines is really ſurprizing, which is continued from the ſtomach through the guts to the anus. The various ramifications of the veins and arteries, which are white, and a regular pulſe may be alſo diſcerned. From its head proceeds two hairy horns B B, fig. 159. with four joints. Its two black eyes are ſhewn at C C, fenced round with ſeveral ſmall hairs; it has ſix legs, covered with a very tranſparent ſhell, and jointed exactly like a crab's or lobſter's claws; each leg hath five joints with ſeveral ſmall hairs interſperſed about them; at the end of each is two ſharp hooked claws, as may be ſeen in the figure, unequal in length and ſize; one of which reſembles that of an eagle, but the other of the ſame foot [p] ſtands ſtrait out, and is very ſmall; between theſe two is a raiſed part or knob, moſt exquiſitely contrived for performing thoſe motions of walking and climbing up the hairs of the head; for when it walks, by having the leſſer claw G ſet ſo much ſhort of the bigger H, that the former does not touch, and by means of the ſmall joints in the latter, it is able to bend it round, and ſo with both claws to graſp and hold faſt the hairs [q]. From its ſnout at the hole D, when the louſe is going to feed, it puſhes out a pointed

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[o] Phil. Tranſ. No. 284. [p] Ibid. No. 94. [q] Hook's Micro. p. 212.

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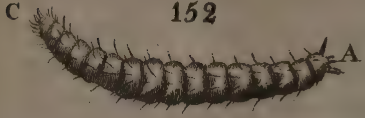

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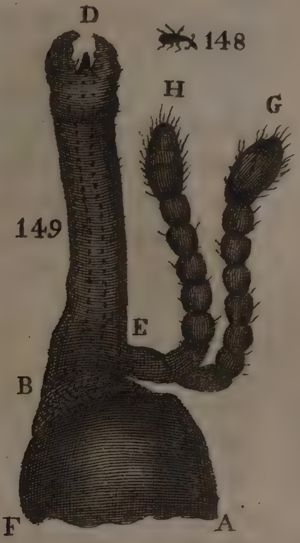

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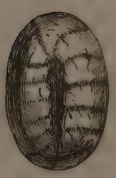

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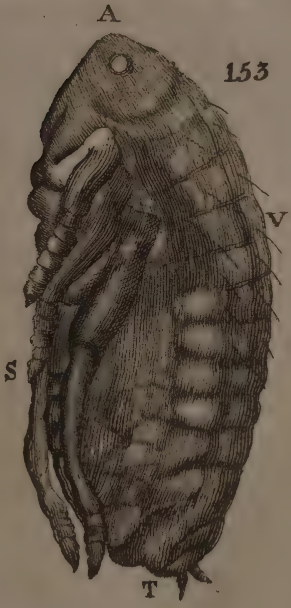

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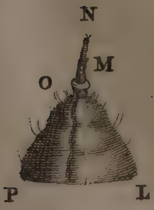

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pointed part, which is repreſented at fig. 157. whereof L O P is the ſnout part of the louſe's head. At O is the nipple, from whence the ſheath, or caſe M, and from within this alſo, the piercer [r] or ſucker N is puſhed out; at N, its point is ſomewhat cleft. Theſe are thruſt into the ſkin to draw out the blood and humours it feeds on; for Mr. Hook placed a louſe upon the back of his hand that had been faſting two or three days, which immediately thruſt its ſucker into the ſkin, and he could plainly ſee a ſmall current of blood come directly from its ſnout in a fine ſtream to the fore part of the head, and then to fall into a roundiſh cavity; it paſſes again in a like ſtream to another circular receptacle in the middle of the head at A, from thence through a ſmaller veſſel to the breaſt; and then to a gut that reaches to the hinder part of the body, where in a curve it turns a little upwards. In the breaſt and gut the blood without intermiſſion is moved with great force, and in the gut with ſuch a ſtrong propulſion downwards, and ſuch a contraction of the gut as is ſurprizing. In the upper part of the crooked aſcending gut the propelled blood ſtands ſtill, and ſeems to undergo a ſeparation [s]; part of it becoming clear and wateriſh, while certain little black particles paſs downwards to the anus. The thorax is caſed with a tranſparent horny ſubſtance, through which the blood was variouſly diſtributed; and at I, appeared a pretty big white ſubſtance; many very ſmall milk-white [t] veſſels were diſcernable between its legs, out of which on either ſide were many minute branchings. The belly is covered with a thin tranſparent ſkin; at the upper end of this its ſtomach K K is placed, and the white ſpot L;

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[r] Leeuwenhoek's Exp. & Con. p. 354.

[s] Phil. Tranſ. No. 102.

[t] Hook's Micro. p. 213.

at the extremity of the tail are two ſemicircular parts covered all over with hair.

Place a louſe on its back and two darkiſh bloody ſpots will appear: the larger in the middle of the body, and the leſſer towards the tail. In the larger ſpot a white film [u] or bladder contracts, and dilates upwards and downwards from the head towards the tail; the pulſe of which is followed by a pulſe of the dark bloody ſpot, in or over which the white bladder ſeems to lie. This motion of ſyſtole and diaſtole is ſeen beſt when the louſe is grown weak; the white pulſing bladder ſeems to be the heart, for on pricking it the louſe inſtantly dies. The lower darkiſh ſpot is thought to be the excrement in the guts.

The males have ſtings [x] in their tails, the females none: the females lay eggs or nits, from whence lice are produced perfect in all their members, and undergo no farther change.

Mr. Leeuwenhoek obſerved that in ſix days one of them had laid fifty eggs, and diſſecting it, he ſaw as many more in the ovary; concluding from thence that it would have laid an hundred eggs in twelve days. Theſe eggs hatched in ſix days, would probably produce fifty males and as many females; and theſe females coming to their full growth in eighteen days, might in twelve days more probably lay an hundred eggs alſo, which eggs in ſix days farther, the time required to hatch them, might produce a young brood of five thouſand; ſo that in eight weeks a louſe may ſee five thouſand [y] of its own deſcendants.

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[u] Power's Micro. Obſ. p. 9. [x] Arc. Nat. Tom. ii. p. 77.
[y] Ibid. p. 77. [z] Arc. Nat. Tom. i. p. 78.

Upon an oblong ſlip of glaſs, a louſe may be eaſily diſſected in a ſmall drop of water and applied to the microſcope; thus five or ſix eggs ready to be laid may be found in the ovary of a female, with many others of a leſs ſize. In the male the penis is remarkable, and alſo the teſtes, whereof it has a double pair. The females appear very white if faſting, and even when fed are leſs red than the males.

The vermin adhering to and feeding on the bodies of different animals, are commonly called lice.

Inſects are infected with vermin that feed [a] on and torment them; ſeveral beetles have lice on them.

The earwig is troubled with minute inſects, which ſtick like lice on the ſeveral parts of the body, eſpecially under the ſetting on of its head. They are white like mites, but ſmaller; are round backed, flat bellied, long legged, eſpecially the two foremoſt; the ſame has not been obſerved on any other animal.

Snails of all kinds have inſects feeding on them. Small red lice are frequently to be ſeen about the legs of ſpiders.

White lice are commonly found on humble-bees, on ants, on fiſhes, &c. and probably very few creatures are free from them.

The polipe alſo is not exempt from vermin of this ſort.

There is another ſort of louſe found about unclean people, called a crab-louſe.

Seignior Redi at the end of his treatiſe De Generatione Inſecto, hath obliged us with microſcopic drawings of ſeveral ſorts of lice, that feed upon the bodies of different animals, to which I refer the reader.

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[a] Phil. Tranſ. No. 288.

In the hawk and turkey hen he obſerved three ſorts, four in the wild duck, in the wild gooſe, ſwan, keſtrel, and plover two; yet there are ſeveral ſorts of birds which have either the ſame ſort of lice, or ſome nearly like them. The keſtrel hath a ſort of lice differing only in colour from thoſe of the raven; and the raven others, like thoſe found upon the egret: on the wood-pecker and chafinch are ſome reſembling thoſe of the ſtarling; on the large wild duck are ſome much like thoſe of the wild gooſe. It is alſo obſervable, that the bigneſs of each bird's lice bears no adequate proportion to the bigneſs of the birds they are found upon; but that on the largeſt birds both large and ſmall lice of different kinds may be found; for on the black-bird hath been ſeen ſome as large as thoſe on the ſwan.

There is alſo a little animal in ſhape and colour like a louſe, commonly found among the leaves and covers of books, and in rotten wood; it has a ſwift motion and runs by ſtarts; it is called a wood-louſe [b] or wood-mite. If this animal be ſtuck upon the point of a very fine ſewing needle with a little turpentine, it will be found a very curious object; its whole body being caſed in annulary circles, full of ſilver hairs, eſpecially towards the tail, with ſix legs, that terminate in two talons; it hath two horns, but pointing backwards; its eyes are of a golden colour, and puſhed out or drawn in at pleaſure; it hath alſo two pointers before like a pair of pincers.

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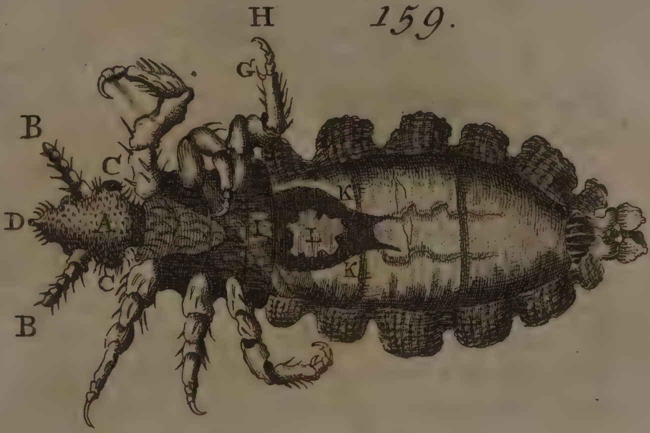
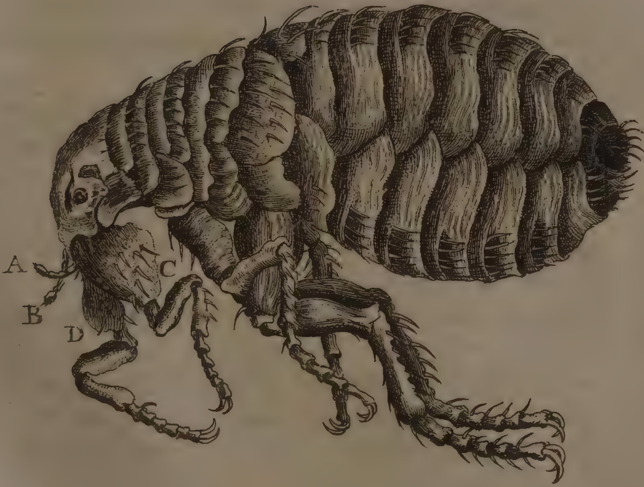
[b] Power's Micro. Obſ. p. 10.

Pl. 33.

159.



158.



Front.^{g} Pag. 94. T. Bowles sc.

Of mites.

THEY are cruſtaceous animals, having a ſmall head in proportion to their bodies, a ſharp ſnout and mouth like that of a mole [c], when open it appears red; they have two little eyes, ſome have ſix legs, others eight, each of which terminate in two hooked claws: the diviſions of the head, neck, and body are eaſily diſcernable by the microſcope; the hinder part of its body is plump, and of an oval form, with a few exceeding ſmall hairs iſſuing therefrom, and from other parts of its body alſo. The female lays eggs, the young ones iſſue forth with all their members perfect, though extremely minute; they caſt their ſkins ſeveral times before they attain their full growth.

Fig. ~~106~~ 160. repreſents one of the mites in cheeſe; its head is ſeen at A, and exactly anſwers the deſcription before given. One of a mite's eggs is ſeen at fig. 165.

They may be kept alive many months between two concave glaſſes, and applied at pleaſure to the microſcope; by often looking at them they may frequently be ſeen in coitu [d], conjoined tail to tail, for though the penis of the male be in the middle of the belly, it turns backwards like the rhinoceros. The coitus is performed with an incredible ſwift motion. In warm weather their eggs hatch in twelve or fourteen days; but in winter-time and cold weather not under ſeveral weeks: the young ones may be frequently ſeen near a day ſtruggling to get clear of their egg-ſhell.

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[c] Power's Mic. Obſ. p. 16.

[d] Arc. Nat. Tom. iv. p. 360.

Of

Of the wandering mite.

THESE creatures appear to the naked eye to be a kind of black mite, though much nimbler and ſtronger than the cheeſe mites, but on viewing them in the microſcope, they will be found to be a very fine cruſtaceous inſect, like fig. 161. with a protuberant oval ſhell indented with ſeveral ſmall pits, covered all over with white briſtles; they have eight legs, each of them furniſhed with a ſharp claw at the end. The thorax was covered by two ſhells, its ſnout taper with a knobbed ridge [e] running along the middle of it; juſt over each of its eyes aroſe two very long and ſtrong briſtles, its eyes black and ſmooth like thoſe of bigger inſects. Theſe mites are to be met with on almoſt any ſubſtance where they can get food.

Another ſort of mite as delineated by Dr. Hook, is repreſented in fig. 162, covered with a curiouſly poliſhed ſhell, which reflected the light from all ſides.

Theſe creatures are very much diverſified in ſhape and colour, and in ſeveral other circumſtances, according to the nature of the ſubſtance out of which they ſeem to be fed [f], being in one longer, in another rounder, in ſome more hairy, in others ſmoother, in this nimble, in that ſlow, here pale and whiter, there browner, blacker, or more tranſparent. They are to be met with almoſt on all kinds of ſubſtances that are mouldy or putrifying, in oatmeal, and in malt-duſt; there are mites bred among figs [g], in hay, and in the powder that falls off dried roots [h]. They are voracious animals, and devour not only cheeſe, but alſo all ſorts of dried fleſh, fiſh, fruits, and grain, and almoſt every thing beſides that has a certain degree of moiſture, without being over-wet. Fig. 164. repreſents a ſmall hair of a mite as delineated by Mr. Leeuwenhoek, which a certain gentleman compared to an Indian or Japan cane [i], with ſeveral joints, and ſaid it appeared to him through the microſcope as if ſharp twigs were ſprouting out of each joint. And fig. 163. repreſents another hair or briſtle of a mite magnified, which was ſpicated, or bearded like the ear on the ſeed-beard of ſome graſs. Every briſtle on its body and legs had the ſame formation; yet all mites are not ſo; for of ſeven or eight which were incloſed together, but one of them was found whoſe briſtles were all of this make, in the reſt the horns only were ſpicated.

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[e] Hook's Micro. p. 206.
[f] Ibid. p. 214.
[g] Phil. Tranſ. No. 333.
[h] Power's Micro. Obſ. p. 18.

Their mouths open horizontally to the right and left, like that of a waſp; ſeveral of them being ſhut up together without food for ſome days, ſome were found dead, and the ſurvivors preying on them; by which means their manner of feeding [k] was obſerved, which is very remarkable; for they thruſt one mandible forwards, and draw the other backwards at the ſame time, and thus they do alternately; ſo that they ſeem to grind their food. After feeding they munch or chew the cud.

Mr. Leeuwenhoek hath obſerved that mites in cheeſe turn into aurelias, and from thence to flies; when they turn into aurelias [l] they are incloſed in a thin tranſparent membrane, which in ſome meaſure ſcreens them from the inſults of the maggots that ſwarm in cheeſes. He alſo obſerved ſome of the flies produced from theſe cheeſe-worms, that he kept in a glaſs tube in which he had put cheeſe

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[i] Power's Micro. No. 333. [k] Ibid. No. 284. [l] Ibid. No. 262.

cheeſe for them to feed upon, had coupled; and ſoo after laid eggs of an oblong figure, and then died: from theſe eggs came young worms, which alſo fed on the cheeſe, and when he judged them to be at their full growth, and the weather began to be cold, he took ſix of the biggeſt, and carried them about him; and a few days after he obſerved that four of them were changed into aurelias, that two worms were dead, and two flies ſkipping about the glaſs; he repeated the ſame thing in January, and with the like ſucceſs; when he kept them in the cold, little or no ſign of life or motion appeared; but as ſoon as he put them into his pocket, they were as briſk as in ſummer. Upon opening an aurelia that had never produced a fly, a dead one was found within it, which had been making its efforts to get out, but was not ſtrong enough to effect it.

Theſe vermin creep into the cabinets of the curious, and deſtroy their choice collections of inſects: but to prevent this, keep in your drawers, &c. a continual ſupply of camphire, whoſe hot and dry effluvia will penetrate, ſhrivel up, and deſtroy the tender bodies of theſe little miſchievous plunderers.

Of a crab-like inſect.

THIS inſect is about the bigneſs of a large mite, and of a very curious form, as delineated in fig. 167; it had ten legs, eight of which a a a a terminated in very ſharp but double hooked claws, being thoſe it walked upon, which were ſhaped much like thoſe of a crab: the two other claws A A, that were the foremoſt of all the ten, ſeemed to branch out from its head, and were exactly formed like crabs, or lobſters claws, as are expreſſed in the figure, whoſe ends terminated in a pair of pincers, (with which I have often ſeen him ſtroke thoſe other claws E E) which grew out of his ſnout; in walking the creature elevated the former above its head and body; its eyes were ſituated about d d, its head was covered with a kind of ſcaly [a] ſhell at F, its thorax G G with two ſmooth ſcales, and its back with eight knobbed ones H H. Theſe inſects are frequently to be met with amongſt books and papers that come from China, when firſt unpacked.

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[a] Hook's Micro. p. 208.

Of the ſemen maſculinum.

SPONTANEOUS generation is a doctrine ſo generally exploded, that a diſproof of it is altogether needleſs in this place, it being put beyond all diſpute that all animals and vegetables owe their production to parent animals and vegetables; and that animals are from animalcula [o]. Theſe animalcula being originally in the ſemen of the male, and not in the female; therefore can never come forward or be formed into animals of their reſpective kinds, without the ova in the female [p].

By the aſſiſtance of a good microſcope, myriads of animalcules may be diſcovered in the ſemen maſculinum of animals, alive and vigorous; though ſo exceedingly minute, that it has been computed 3,000,000,000 of them are not equal to a grain [q] of ſand.

The general appearance of the animalcules in the ſemen maſculinum of different creatures is very much the ſame, that is, their bodies all ſeem to be of an oval form, with long tapering ſlender tails iſſuing therefrom, ſomewhat reſembling tadpoles: though their tails in proportion to their bodies are much longer than thoſe of tadpoles. And the animalcules in the ſemen of fiſhes have tails ſtill longer and ſlenderer than either, inſomuch that the extremity of them is rarely to be diſcerned. Their general appearance as above deſcribed is ſhewn fig. 187.

Mr. Leeuwenhoek, upon viewing the milt of a cod fiſh [r] with a microſcope, obſerved therein ſuch prodigious numbers of living animalcula, with long tails inceſſantly moving to and fro, (he obſerved the ſame thing in the milts of pikes or jacks) that according to his computation 10,000 of them might be contained in the quantity of one grain of ſand [s]. Whence he argues, that there are more living animalcula in the milt of one cod-fiſh, than there are people alive upon the face of the whole earth, at one and the ſame time. He computes one hundred grains of ſand to make the diameter of an inch, then a cubic inch will contain a million of ſuch ſands. And as he found the milt of the cod-fiſh to contain fifteen inches, it muſt contain fifteen millions of quantities as big as a grain of ſand; and if each of theſe quantities contain 10,000 animalcules, the whole muſt contain one hundred and fifty thouſand millions. Then to calculate the number of people, he reckons a great circle to contain 5,400 Dutch ſquare miles: whence he calculates the earth's ſurface to contain 9,276,218 ſuch ſquare miles: and ſuppoſing one third of the whole or 3,092,072 miles to be dry land; and of this two thirds or 2,061,382 miles to be inhabited. And ſuppoſes farther, that Holland and Weſt-Frizeland are twenty-two miles long, and ſeven broad, which makes 154 ſquare miles: the habitable part of the world is then 13,385 times the bigneſs of thoſe places.

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[o] Phil. Tranſ. No. 192.

[p] Vide Harris's Lex. Tech. under the word Generation.

[q] Vide Keil's Anat. p. 116.

[r] Phy. Collections, No. 1. p. 3.

If the people in theſe two provinces are ſuppoſed a million, and that all the other parts of the world are as populous as theſe, which is improbable, there would be 13,385 millions of people on the face of the whole earth: but the milt of this fiſh contained 150,000 millions of animalcules, which is ten times more than the number of mankind.

The ſeminal veſſels of a cock [t] being opened, and a ſmall drop of the ſemen ſqueezed out, and applied to the microſcope,

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[s] Arc. Nat. Tom. i. Part ii. p. 9.

[t] Phil. Tranſ. No. 279.

microſcope, great numbers of animals were ſeen ſwimming therein in legions, and croſſing one another like clouds in a ſtormy day, as briſk as if the cock was newly dead [u], although it was killed the day before; they appear as at fig. 168. if viewed with due attention, and with the greateſt magnifiers, otherwiſe only in the form of eels.

Mr. Leeuwenhoek, in the ſpring-time, when the frogs engender, opened the teſticles of the male [x], and on applying ſome of the ſeminal matter to the microſcope, multitudes of animalcules appeared therein, about one thouſandth part of the thickneſs of a human hair; and there ſeemed to be ten thouſand of them at leaſt to each one of the female ova; their form is as repreſented in fig. 169.

Mr. Leeuwenhoek's method of computing the ſize of animalcules was this, he placed an hair [y] of his head near them, which hair appeared an inch in breadth; and being ſatisfied that ſixty of the animalcules could lie within that diameter; whence their bodies being ſpherical, 216,000 of them are but equal to a globe, whoſe diameter is no more than the breadth of ſuch an hair. Another method of his alſo follows.

He firſt ſuppoſed a drop of water equal to a pea; then took a little quantity of water, of a round figure, as big as a millet grain; and reckoned this to be one ninety-one part of a pea [z]; for when the axis of a millet ſeed makes one, that of a pea will make four and half, whence it follows, that the ſeed of a millet is at leaſt the one ninety-one part of a pea; this ſmall quantity of water he put into a very ſlender glaſs tube, dividing by this means that little water into twenty-five or thirty parts, and found more than an hundred animalcula in the one thirtieth part of water, equalling the bigneſs of a millet ſeed. Whence it appears, that if one thouſand are to be ſeen in the one thirtieth part of a millet ſeed, there may be ſeen thirty thouſand in one ſuch whole ſeed; and conſequently in a drop of water ninety-one times bigger, there may be ſeen 2,730,000. Beſides he compared the water to the bulk of a grain of ſand; that if the axis of a grain of ſand be one, that of a drop of water is at leaſt ten, conſequently a drop one thouſand times bigger than that grain of ſand, and therefore there are 1,000,000 of animalcula in one drop of water, at the rate of one thouſand little animals in that quantity of water.

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[u] Arc. Nat. Tom. ii. Part. ii. p. 369.

[x] Arc. Nat. Tom. i. Part. i. p. 51.

[y] Phil. Tranſ. No. 270.

[z] Ibid. No. 131.

[a] In the ſame manner he alſo computed that 4,096,000 eggs were in the roe of a crab. Each of which received its nouriſhment by a ſtring from the crab's body.

To view the animalcules in the milt or ſoft roes of fiſhes, ſqueeze out a little of it, and putting the quantity of a pin's head upon a glaſs, dilute it with river or rain-water, till they have ſufficient room to ſwim freely about, and ſhew themſelves to advantage.

N. B. the eggs. [b] in the roe and animalcules in the milt of fiſhes of one year old, are as large as in thoſe of the ſame ſpecies of twenty years old.

Some of the ſeminal matter taken from the teſticles of a dog [c], abounded with animalcules in form of fig. 170. and ſome of them remained alive after having been kept ſeven [d] days in a glaſs tube.

The teſticles of a hare, although four days [e] dead, were found to be exceeding full of animalcules, like thoſe

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[a] Arc. Nat. Tom. i. Part ii. p. 339. [b] Ibid. Tom. iii. p. 188. [c] Ibid. Tom. i. Part. ii. p. 160. [d] Ibid. p. 150, and 49. [e] Ibid. Tom. i. Part ii. p. 160.

thoſe in dogs, ſwimming in a clear liquor, but without motion.

A female rabbit being killed immediately after the coitus, and the uterus opened, innumerable quantities of animalcules were found in a ſmall drop taken from the mouth of the fallopian tube, where it opens into the matrix; but none were diſcerned in the uterus itſelf, or farther along the tube; they had long tails, and moſtly [f] ſix tranſparent globules appeared on the body of each, as in fig. 171. A; though ſome had only one globule at the end of the body, and another in the tail, as fig. 171. B.

A buck being killed in rutting-time, the vaſa deferentia were found turgid, and full of a milky fluid, a drop of which diluted with a drop of warm water, juſt enough to change its colour, and then applied before the microſcope, appeared full of animalcules moving very briſkly [g].

A drop of the ſeminal matter taken from the teſticles of a ram, flowed with animalcules in as great numbers as that of other creatures; but with this difference, that they ſwam in droves together the ſame way, and ſeemed to follow their leader [h] as ſheep do. Mr. Leeuwenhoek found ſo much pleaſure in this obſervation, that he called in ſome neighbours to ſhare it with him.

This ingenious enquirer after nature, opened the uterus of an ewe, about ſeventeen days after ſhe had been coupled with a ram; and in one of the cornea obſerved a little reddiſh fleſhy ſubſtance, wherein no ſhape could be diſtinguiſhed, which he extended very gently out of the round in which it lay, and could plainly perceive the formation of all the vertebræ, with the blood-veſſels and ramifications paſſing over them, and could ſee the ſpinal marrow in two places [i], and diſtinguiſhed not only the head, but alſo the mouth, brain, and eyes, the bigneſs of two grains of ſand, and clear as cryſtal; he likewiſe ſaw the ribs and inteſtines, though the whole creature was no longer than the eighth part of a pea. After which he opened the uterus of another ewe [k], three days from the coitus, and ſearching the liquor coming therefrom with a magnifying glaſs, obſerved a little particle the ſize of a grain of ſand; and examined it with a very good microſcope, and with great pleaſure found it to be an exceeding minute lamb, lying round in its integuments, and could plainly diſcern its mouth and eyes.

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[f] Arc. Nat. Tom. i. Part ii. p. 168. [g] Phil. Tranſ. No. 284. [h] Leeuwenhoek's Epiſt. Phy. p. 388.

The human ſemen has alſo been viewed by the microſcope, and found to be as plentifully ſtocked with animalcules, as that of other animals: Mr. Leeuwenhoek has ſeen more than ten thouſand living creatures moving in a quantity of the fluid part thereof, no bigger than a grain of ſand: and in the thicker parts, they were ſo thronged together, that they could not move for one another; their ſize was ſmaller than the red globules of the blood, and even leſs than a millionth part of a grain of [l] ſand, their bodies roundiſh and flat before, as in fig. 172. but ending ſharp behind. Their tails are exceedingly tranſparent, and five times longer, and ſlenderer than their bodies. They move by the agitations of their tails in various windings, after the manner that eels ſwim.

The [m] animalcules in the ſemen maſculinum of all creatures differ but little in ſhape or bigneſs, for which reaſon it follows, that the animalcules may be diſcovered in the ſemen of the ſmalleſt birds, quadrupeds, and fiſhes; nay, and even in inſects to. For Mr. Leeuwenhoek affirms, that he found in the white matter he had ſometimes ſqueezed from the hinder parts of male [n] ſpiders, a prodigious number of animalcules. He found them alſo in the ſemen of the [o] dormouſe, in [p] oyſters, in [q] ſilkworms, in the [r] labella minima, or ſmall dragon fly, the common [t] fly, in the male [t] flea, in [u] gnats, and many other inſects [x].

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[i] Arc. Nat. Tom. i. Part ii. p. 164.

[k] Ibid. p. 173.

[l] Arc. Nat. Tom. ii. Part ii. p. 61, 96, 286.

[m] Ibid. Tom. iv. p. 30.

It is obſervable that amongſt the many ſpecies of animalcules found in waters, and other infuſions, there are none like thoſe in ſemine; but that theſe laſt, in all ſorts of creatures, have a general likeneſs to each other, and appear in continual motion without any intermiſſion, if the fluid be but ſufficient for them to ſwim in.

It is farther obſervable, that no animalcules can be found in the blood, ſpittle, urine, gall, chyle, or any other of the humours, except the ſemen only.

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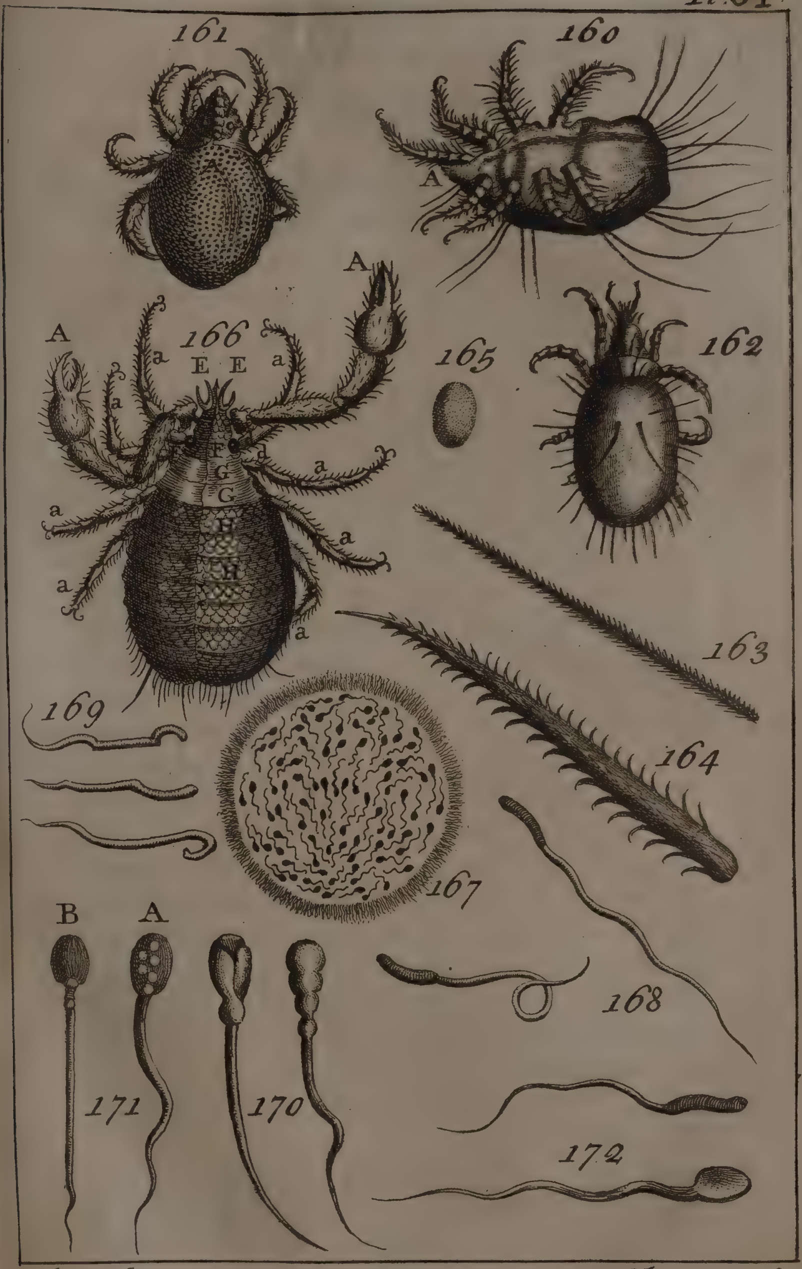
[n] Phil. Tranſ. No. 279. [o] Arc. Nat. Tom. i. Part ii. p. 27. [p] Ibid. Tom. ii. Part i. p. 144. [q] Ibid. Part ii. p. 442. [r] Ibid. Tom. iv. p. 19. [s] Ibid. [t] Ibid. p. 20. [u] Ibid. p. 22. [x] Ibid. p. 294.

Pl. 34.



Front.⁹ Pag. 106 T. Bowles sc.

Of the oyſter.

MANY little round living animalcules have been found in the clear liquor of an oyſter [y], ſuppoſed to be the animalcules in the roe or ſemen.

Mr. Leeuwenhoek opened an oyſter on the fourth of Auguſt, (which is the time that oyſters are ſuppoſed to breed) and took out of it a prodigious number of minute oyſters, all alive and ſwimming briſkly in the liquor, by the means of exceeding ſmall organs, extending a little way beyond their ſhells, which he calls their beards; in theſe he could diſtinguiſh the joining of the ſhells, and perceived ſome that were dead, with their ſhells gaping, and as like large oyſters in form as one egg is like another.

Upon opening a female oyſter, incredible multitudes of minute oyſters, covered with little ſhells, perfectly tranſparent, were plainly ſeen therein; in another they were found of a browniſh colour, without any apparent life or motion.

Monſ. Azout obſerved a ſhining clammy matter, which ſtuck to the ſhells of oyſters, and being drawn out, ſhone [z] in the air its whole length, which was four or five lines, and continued ſo for a conſiderable time when laid on the obſerver's hand, and afterwards opening more than twenty dozen in the dark, and then examining ſome of this ſhining matter with a microſcope, he found it to conſiſt of three ſorts of real worms. One was whitiſh, having twenty-four or twenty-five forked feet on each ſide, with a black ſpeck on one ſide of the head, taken by him for a cryſtalline, its back like an eel ſtripped of its ſkin; the ſecond was red, reſembling the common glow-worm, with folds on its back, legs like the former, and a noſe like that of a dog's, and one eye; the third ſort was ſpeckled, with a head like a ſoal, and many tufts of whitiſh hair on its ſides. There was a bigger ſpecies, that was greyiſh with a big head, and two horns like thoſe of a ſnail; it had ſeven or eight whitiſh feet, but theſe ſhined not.

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[y] Arc. Nat. Tom. ii. Part i. p. 52.

[z] Phil. Tranſ. No. 12. p. 203.

The two former conſiſt of a matter eaſily diſſolvable, the leaſt touch turning them into a viſcous and aqueous matter, which falling from the ſhell, ſtuck to the obſerver's fingers, and ſhone there for twenty ſeconds. If any part of it fell to the ground it appeared like a ſmall piece of flaming brimſtone, and when ſhook off nimbly, it ſeemed a ſmall ſhining line, which was diſſipated before it reached the ground. Some of it was whitiſh, ſome reddiſh, but both afforded a violet colour to the eye. The worms give no light when irritated; and if they do, it laſts but a little while: whereas in thoſe that are not provoked, it continues a good while.

As tainted fleſh, rotten wood, bodies of lobſters, and ſome other kinds of fiſhes, and other ſubſtances, are ſometimes found to ſhine with a light reſembling the foregoing, may it not probably proceed from the ſame cauſe, viz. from animalcules? Some have alſo ſuppoſed, that the Ignis Fatuus, will in a wiſp, or jack in a lanthorn, is nothing elſe but a ſwarm of minute inſects, that emit light round them in the manner glow-worms do.

Of the muſcle.

IN a diſſection of the ovarium of a muſcle, Mr. Leeuwenhoek diſcovered numbers of embrio muſcles [a], which appeared as plainly in the microſcope as the muſcle does to the naked eye; lying with their ſharp ends faſtened to the ſtrings or veſſels whereby they received their nouriſhment. Theſe minute embrio muſcles are in due time laid or placed by the parent, in a very regular and cloſe order, on the outſide of the ſhell; where, by means of a glewy matter, they adhere very faſt, and continually increaſe in ſize and ſtrength; till becoming perfect muſcles, they fall off and ſhift for themſelves, leaving the holes where they were placed behind them, as abundance of muſcle ſhells when viewed by the microſcope can ſhew two or three thouſand of theſe eggs adhering ſometimes to the ſhell of one muſcle; it is not certain they are all fixed there by the muſcle itſelf, but are frequently placed there by another muſcle. The fringed edge of the muſcle, called by Mr. Leeuwenhoek the beard, has in every the minuteſt part of it ſuch a variety of motions, as is unconceivable; for being compoſed of longiſh fibres, each fibre has on both ſides a vaſt many moving particles, which one would almoſt imagine to be animalcules [b].

The ſtrings or threads, which we term the beard, are compoſed of a glew, which the muſcle applies by the help of its trunk to ſome fixed body, and draws out as a ſpider does its web, thereby faſtening itſelf, that it may not be waſhed away. If muſcles be put into ſalt and water, they will faſten themſelves to the ſides of the veſſel we place them in.

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[a] Phil. Tranſ. No. 336.

[b] Phil. Tranſ. No. 336. Arc. Nat. Tom. ii. p. 19. & Tom. iv. p. 423.

Scallops, cockles, limpets, perriwinkles, and abundance of other ſhell-fiſh, are objects that have as yet been very ſlightly examined by the microſcope; and therefore the ſerious enquirer into nature's ſecret operations may here be certain of diſcovering beauties, which at preſent he can have no conception of.

Of the itch.

DOCTOR Bononio hath diſcovered that this diſtemper owes its riſe to little inſects [c] under the cuticula, whoſe continual bitings cauſe an ouſing of the ſerum from the cutis, and produce thoſe puſtules whereby the diſeaſe is known.

For on obſerving people in this diſtemper pull out of the ſcabs, little bladders of water with the point of a pin, and crack [d] them like lice upon their nails, from a place ſcabbed over, and where there was a grievous itching, he picked out a little puſtule, and from thence ſqueezed a thin matter, in which he could but juſt diſcern a ſmall white globule; but on applying it to his microſcope, found it to be a minute animal of a whitiſh colour, in ſhape reſembling a tortoiſe, but ſomewhat dark on its back; it is repreſented in fig. 173, at A and B; they have ſome long hairs, ſix legs, a ſharp head, and two horns, and are very nimble. He repeated this on perſons of all ages, ſexes, and complexions, and at all ſeaſons of the year, and found the ſame ſort of animals in moſt of the watery puſtules. They begin to enter in the furrows of the cuticula by gnawing and working in their heads till they are quite got under, where they cauſe a grievous itching, and force the infected perſon to ſcratch, which only heightens the malady: from his frequent obſervations he alſo ſaw one of them drop an egg, almoſt tranſparent, from the hinder part of its body, and afterwards ſaw ſeveral others of the ſame ſort, one of which is repreſented at C, fig. 173.

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[c] Bonani Micro. p. 91.

[d] Phil. Tranſ. No. 283.

Hence follows the reaſon why this diſtemper is ſo very catching, ſince by ſimple contact theſe animals can readily paſs from one perſon to another, not only from their ſwift motion, but by their clinging to every thing they touch; and crawling as well upon the ſurface of the body, as under the outward ſkin. A few being once lodged, they multiply apace by their eggs; nor is it any wonder if this infection is alſo propagated by the ſheets, towels, handkerchiefs, or gloves, uſed by itchy people; ſince theſe animalcules may eaſily be harboured in ſuch things, and will live out of the body two or three days.

This diſcovery alſo accounts why this diſtemper is never cured by internal medicines, but requires lixivial waſhes, baths, or ointments, made up of ſalts, vitriols, mercury, ſulphur, precipitate or ſublimate, or ſuch kinds of corroſive and penetrating remedies as can powerfully kill theſe vermin in their ſkin. It is neceſſary to continue the anointing for ſome days after the cure ſeems perfected; for though the ointment may have deſtroyed all the living animalcules, it may not probably have killed their young in the eggs, which are laid in neſts in the ſkin, which if ſuffered to be hatched may renew the diſtemper.

Of

Of animalcules in the teeth.

THESE are to be found in great numbers of different kinds, in the whitiſh matter that ſticks between the teeth of men, women, and children[e]; but eſpecially between the grinders, although they waſh their teeth frequently; but from people that are more careleſs, a ſort of eels are found. The firſt ſort A, fig. 174. move along very ſwiftly, in ſpittle or water without bubbles. The ſecond ſort ſeen at B, fig. 174. move in the direction of the doted line. The third ſort is ſeen at E, and the fourth ſort at F.

They all die if vinegar be put to them; from whence it ſeems probable, that if the teeth and gums be frequently waſhed with it, it may be a means to preſerve them from theſe creatures.

Of the ſnail.

THIS ſlow paced ſlimy animal hath many curious obſervables. The firſt are its four eyes, like atramentous ſpots, fixed at the ends of its horns, or rather at the ends of thoſe black filaments, or optic nerves[f] that are ſheathed in its horns, which it can thruſt out, draw in, turn, or direct as it finds occaſion. If when the horns are fully extended, you nimbly clip off their extremity, and place them before the microſcope, either upon the object carrying glaſs, or ſtick the end of them with a little turpentine to the point, they may very eaſily be examined in the microſcope, with all the magnifiers, and will be found to be two hemiſpherical eyes. And when the ſtump is re-extended, it will appear evidently hollow, or tubular to the naked eye.

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[e] Leeuwenhoek's Ex. & Con. p. 40. Tom. iv.

[f] Power's Micro. Obſ. p. 36. Spect. de la Nat. Dial. xi.

Snails partake of the nature of both ſexes, inſomuch that as ſoon as one has impregnated the other, the ſame act of generation is immediately returned; each of them, eighteen days after theſe approaches, drop and conceal their eggs in the earth; the young of which, when hatched, appear with ſhells compleatly formed [g].

If you would view the internal fabrick of this animal, the microſcope will, after a dextrous diſſection, diſcover to you the heart, juſt againſt a round hole near the neck, which probably is the place of reſpiration; the heart may be ſeen to beat near a quarter of an hour after diſſection. [h] Its guts are green (from the herbs it eats) and curiouſly branched over with fine capillary white veins. This creature, how contemptible ſoever it may ſeem, hath a compleat ſett of the ſame parts and organs with other animals, as heart, liver, ſpleen, ſtomach, guts, veins and arteries.

If the head be cut off, a little ſtone will be found, ſaid to be of a diuretic quality, and of ſingular ſervice in gravelly diſorders.

They have a mouth like a hare or rabbit, and teeth as repreſented in fig. 175. whereof A B C ſhew the upper jaw, which is white, and of a ſemicircular form; the lower black part C D E, hath ſeveral prominent parts or teeth F F F, but all fixed together ſo as to compoſe the ſame bone. Mr. Hook obſerved this very ſnail (of which the figure now before us is a picture of its teeth) to feed on the leaves of a roſe-tree, and to bite out half-round bits of the ſize and ſhape of the letter C.

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[g] Nat. Delin. p. 148. [h] Power's Obſ. p. 38.

If a ſnail be ſuffered to creep upon a bit of glaſs, you may by the naked eye (but better if you apply the hand-glaſs of your microſcope to view it through) obſerve a little cloudy ſtream paſſing from its tail to the head, that never returns the ſame way; and this as long as the ſnail is in motion.

Of the ſcales of fiſhes.

THE outſide coverings of fiſhes are ſcales, formed with inconceivable beauty and regularity; ſome longiſh, ſome round, ſome triangular, ſome ſquare, and ſome or other of all the variety of ſhapes imaginable: ſome again are armed with ſharp prickles, as thoſe of the perch, ſoal, &c. others have ſmooth edges, as the cod-fiſh, carp, tench, &c. There is likewiſe a great variety even in the ſame fiſh; for the ſcales taken from the belly, the back, the ſides, the head, and all the other parts, are very different from each other.

The ſcale of a ſoal fiſh is delineated, as it appear'd in the microſcope, at fig. 176. whereof C D E F repreſents that part of the ſcale which ſhews itſelf on the outſide of the fiſh, and A B C D, the part which adheres to the ſkin, being as it were furrowed, that it might hold the faſter, [i] each of which is terminated on the outſide by pointed ſpikes, and every other of theſe much longer than the interjacent ones.

Mr. Leeuwenhoek ſuppoſes theſe ſcales not to be ſhed during the whole life of the animal; but to have an annual addition of a new ſcale growing over the old one, and extending every way beyond its edges, in proportion to the fiſhes growth: ſomewhat in the ſame manner as the wood of trees enlarge yearly by the addition of a new circle next the bark; and as the age of a tree may be known by its number of ringlets; ſo in fiſhes the number of plates [k] compoſing their ſcales, denote to us their age.

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[i] Hook's Micro. p. 162.

To prepare ſcales for the microſcope, take them carefully off with a pair of nippers, and waſh them very clean, and place them in a ſmooth paper, between the leaves of a book, to make them dry and flat, and then place them in ſliders between the talcs for examination.

The eel, ſnake, viper, lizard, ſlow worm, and the eft, &c. afford a great variety of ſcales. The dog-fiſh ſcales conſiſt of a great number of horny points, which appear in the microſcope to be curiouſly ridged or carved.

Of ſpiders.

THERE are ſo many different ſorts of ſpiders, and their form ſo generally known, that a deſcription of them in this place, cannot be expected. I ſhall therefore proceed to deſcribe ſome of thoſe particulars of this creature, that are only to be diſcover'd with the aſſiſtance of the microſcope.

Some ſpiders have ſix eyes, others eight, others fewer, and ſome more. They all ſeem to be creatures of prey, and to feed on other ſmall inſects, but their ways of catching them are very different. The ſhepherd ſpider by running on his prey; the hunting ſpider by leaping on it; other ſorts weave nets, or cobwebs, whereby they enſnare them. Nature having equipped them both with materials and tools, and taught them how to work and weave their nets, and lie perdue, and to watch diligently, and run on any fly, as ſoon as ever entangled.

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[k] Leeuwenhoek's Epiſt. Phy. Epiſt. 24. Mai, 1716.

Their eyes are immoveable and tranſparent, but not pearl'd; they are ſituated in a moſt curious manner, and deſerve the ſtricteſt examination.

The way to view them is to cut off the legs and tail, and bring only the head part before the microſcope, upon a glaſs ſlip or ſlider, or to ſtick them upon the point, or pinch them between the nippers, and ſo apply them to the microſcope.

They have all eight legs, and two arms, or ſhorter legs near their mouth, that aſſiſt in taking their prey; they are beſet thickly with hairs, have each ſix joints, and end with two hooked claws, ſerrated, [1] or having teeth on their inſide, whereby they cling faſt to any thing; and may be often ſeen to hang down from the branch of a tree, on a thread of their own making, aſſiſted by the help of theſe claws.

Fig. 177. repreſents part of the leg of a ſpider; B, C, D, ſhew the two extreme claws armed with teeth like ſaws; E, the third that hath no teeth. It is certain, that when the ſpider does not wind itſelf by its thread upwards, but runs along its web, it then takes hold of the ſpun thread with this third claw. This ſpider had eight eyes, two of which were on the top of the head, to ſee what paſſes before him: below theſe two others, which look ſtrait forwards; on each ſide of the head were two more, the two foremoſt to ſee collaterally before him, and the two hindmoſt to ſee backwards.

Fig. 182. repreſents that part of the head which contain'd the eyes ſeparated from the membrane in which it lay. P Q, the eyes that look upwards; K L, thoſe that look ſtraight forward; I M, thoſe that look ſideways forward; H N, thoſe that look ſideways backward. They have no eye-lids, but are fortified with a hard, poliſhed, and tranſparent cruſt: as theſe eyes are immoveable, nature hath indulged them with ſo large a number, to give them information of any thing that any ways concerns them.

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[1] Phil. Tranſ. No. 272.

Every ſpider is furniſhed with a pair of forceps, repreſented at A B, and C D, fig. 183. in the fore-part of its head. They ſtand horizontally, and when not made uſe of, they let the claw of them fall down on their reſpective branches, like a knife claſped upon its haft, as at C D, and there they lie between two rows of teeth, that are likewiſe employed to hold faſt its prey.

Authors are divided in their opinions on the poiſon of ſpiders, ſome calling theſe forceps ſtings; as Mr. Leeuwenhoek, who calls the hooked claws A B and C D ſtings; and ſays, that towards their extremity at B and C, are two ſmall holes, from whence, according to all appearance, when it ſtrikes its enemy, it therefrom ejects a liquid matter, we call poiſon.

He put a frog and a ſpider together into a glaſs, and having made the ſpider ſting [m] the frog divers times, the frog died in about an hour's time.

Dr. Mead believes this to be a miſtake, and that while the ſpider bites, a ſhort white proboſcis [n] is thruſt out from the mouth, which inſtils a liquor into the wound.

They frequently caſt their ſkins, which are to be found in cobwebs, in which the forceps may be examined, being always ſhed with the ſkins, and eaſier ſeparated than when alive. They are commonly ſpread out to view, and by their tranſparency, every minute part is ſeen with much diſtinctneſs.

The microſcope hath alſo informed us of the manner how the ſpiders weave their webs, and of their contexture, for the performance of which nature hath endowed them

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[m] Phil. Tranſ. No. 272.

[n] Mead of Poiſon.

them with five little teats, or nipples, near the extremity of the tail; whence a gloomy liquor proceeds, which adheres to any thing it is preſſed againſt [o], and being drawn out, hardens inſtantly in the air, and becomes a ſtring or thread ſtrong enough to bear five or ſix times the weight of the ſpider's body; this thread is compoſed of ſeveral finer ones, that are drawn out ſeparately, but [p] unite together at two or three hair's breadth diſtant from the body of the ſpider. The threads are finer or coarſer, according to the ſize of the ſpider that ſpins them.

Fig. 178. repreſents a part of the threads, which came out of two of their working inſtruments, and were divided from each other, juſt as they iſſue from the body; and R S T V, fig. 179. repreſents one of the four outermoſt inſtruments or nipples, with its quills or reeds, which put together is not ſo large as a common grain of ſand; from whence it is eaſy to conceive, how ſmall thoſe inſtruments muſt be, and how fine the threads encaſed within them. At W theſe working inſtruments ſtood as thick by each other, as they are repreſented between R and S; and that part of the figure from the ſight, was not cover'd with thoſe ſort of quills, but with hairs only. It is alſo obſervable, that a few of theſe inſtruments are bigger than the reſt, and conſequently produce a larger thread. C F, fig. 180. repreſents one of theſe between two others of the ſmaller ſort D E and A B, one of which had a wrinkled or harled thread.

Spiders emit their eggs, not out of the hinder part of their body, as in all other animals, but under that upper part of the belly, near the hind legs, where grows a kind of hook, of a particular figure, which partly covers the aperture from whence the eggs iſſue. Fig. 181. repreſents a ſpider of an ordinary ſize, with its legs contracted, as if it was dead, in order to ſhew the above-mention'd aperture; and at D the hook is ſeen.

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[o] Phil. Tranſ. No. 272. [p] Ibid No. 325.

Fig. 184. G H I K ſhews the hook ſeparated from the ſpider's body, as it appear'd through the microſcope; between I and K are ſeen the wrinkles or folds, which Mr. Leeuwenhoek ſuppoſes are made to produce a more than ordinary motion: E F ſhews the part that join'd it to the body, and between F and G are two round balls. The uſe of which he could not diſcover.

The eggs of ſome ſpiders are a good object, being flattiſh at one end, and round at the other, with a depreſſion at the center of the flattiſh end, and a yellowiſh circle round it; their colour is a blueiſh white like counterfeited [q] pearl; when they hatch, the little ſpiders come out perfectly form'd, and very nimble. They depoſite their eggs to the amount of five or ſix hundred, in a bag ſtrongly compos'd of their own web, which the ſpider either carries under her belly, and guards with the greateſt care, or elſe hides it in ſome ſafe receſs. When juſt hatched, the young ſpiders make an entertaining object for the microſcope.

The current of the blood may be ſeen in the legs and body of ſpiders, as has been before hinted; many other wonders will be diſcover'd by the curious in the diſſection and examination of their ſeveral parts.

The carter, ſhepherd, field, or long-legged ſpider, is different from moſt other ſpiders in two particulars; the firſt, which is only diſcoverable by the microſcope, is the curious contrivance of its eyes; it has only two, and thoſe placed upon the top of a ſmall pillar, riſing perpendicularly out of the middle of its back, or rather the crown of its head. [r] The two eyes, B B, fig. 185. were placed back to back, with the tranſparent parts

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[q] Power's Micro. Obſ. p. 15. [r] Hook's Micro. p. 198.

or pupils more protuberant than the reſt of the circumambient matter, [a] looking towards either ſide, but ſomething more forward than backwards. C, fig. 187. ſhews the column on which they ſtood, and D D the crown of the head.

The ſecond peculiarity is the prodigious length of its legs, which are eight in number, in proportion to its ſmall round body. Each leg of this, of which the figures 185. and 186. are a repreſentation, was above 16 times the whole length of its body; they are jointed juſt like thoſe of a crab; each of which proceeds from a ſmall ſhell-like caſe, of a conical figure, as at I I I I, &c. of fig. 186. which repreſents the under part of its belly; theſe are faſtened on to the protuberant body of the inſect, forming a kind of blunt cone, whoſe apex is at M, about which the ſmaller cones of the legs are placed, each of them reaching almoſt to the top, in ſo admirable a manner, as does not a little manifeſt the wiſdom of nature's almighty architect, in the contrivance thereof. It has two fore claws K K tipped with black like a crab's, which open and ſhut exactly like thoſe in a ſcorpion, and are ſaw-like or indented on the inſide. Its horns are ſeen at A A and mouth at L.

The beſt way to obſerve this ſpider is to cut off all its legs, and place it before the microſcope upon the object-carrying glaſs, or upon the black and white object-plate.

The little white field-ſpider with ſhort legs, found plentifully among new hay, whoſe body appears like white amber, emboſſed with black knobs, out of each whereof grow prickles like whinpricks, ſome have ſix, ſome eight eyes, that may be diſtinctly ſeen, quick and lively;

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[a] Power's Micro. Obſ. p. 14.

Pl. 35

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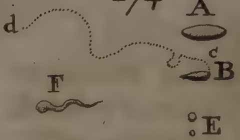

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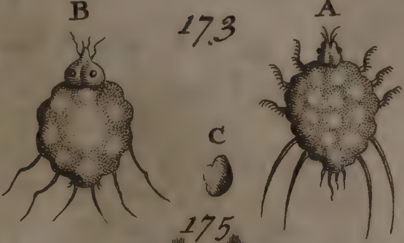

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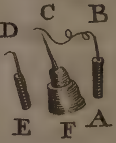

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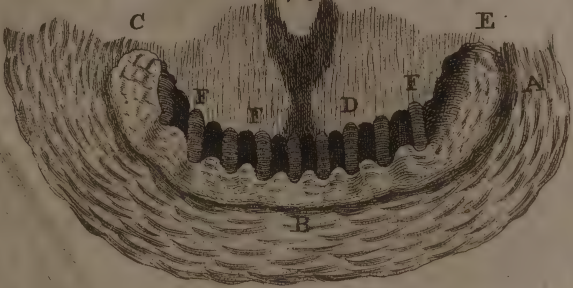

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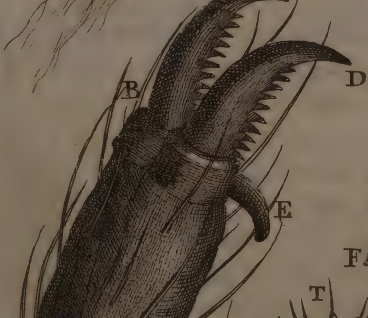

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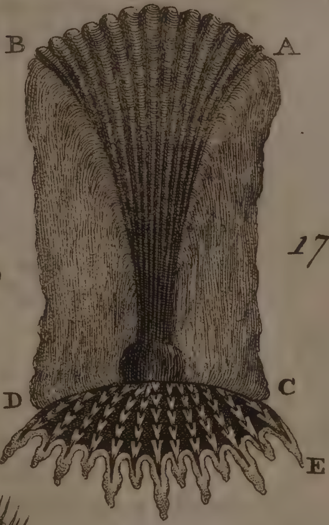

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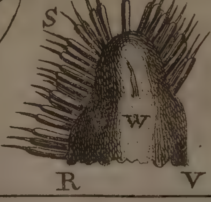

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lively; each eye has a violet blue pupil,[t] clear, and admirably ſurrounded by a pale yellow circle.

The wandering or hunting ſpider, who ſpins no web, but runs and leaps by fits, has two tufts of feathers fixt to its fore paws, which, together with the great variety of colouring all over this animal, affords a beautiful and delightful proſpect for the microſcope.

There is a red mite or louſe often found feeding upon ſpiders, in ſhape much like a tortoiſe,[u] with a little head, and ſix long but ſmall legs; and about the legs of the field-ſpider they cling exceeding cloſe whilſt the animal is alive, but when dead they all fall off and creep away.

Mr. Bon hath made ſeveral pair of ſtockings and gloves, from a ſilk[x] wound off from the egg bags of ſhort legged ſpiders.

Of the ſting and ſcraper of a bee.

AS the contrivance and ſtructure of the ſtings of moſt inſects are nearly alike, they will be ſufficiently underſtood by a deſcription of that of a bee, as diſcovered by the microſcope.

A bee's ſting is a horny ſheath or ſcabbard, that includes two bearded darts; this ſheath ends in a point, near the extremity whereof a ſlit opens, through which at the time of ſtinging, two bearded darts are protruded beyond the end of the ſheath, one whereof being a little longer than the other, fixes its beard firſt, but the other immediately after; they penetrate alternately deeper and deeper, taking hold of the fleſh with their hooks till the whole ſting becomes buried in the wound, and then a venemous juice is injected through the ſame ſheath, from a little bag at the root of the ſting, which occaſions an acute pain, and a ſwelling of the part continues ſometimes for ſeveral days after. This is beſt prevented by enlarging the wound immediately to give it ſome diſcharge, and anointing it with a little common oil.

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[t] Power's Micro. Obſ. p. 13. [u] Power's Micro. Obſ. p. 19.
[x] Phil. Tranſ. No. 325.

A B C, fig. 188. repreſents the ſheath or caſe, out of which the two ſtings or rather ſpears are protruded.[y] E the cavity, in which they lie. C the thickneſs of the caſe below; and about C, A, the two ſpears ſhew themſelves each in a ſeparate place. Fig. 189, ſhews part of the ſting taken out of the ſheath, K its edge or bearded part, L its back without beards. M N, fig. 190. repreſents the whole ſting taken out of the ſheath with its back that is without beards next the eye; the upper part M O is incloſed round about and hollow within, the the lower part O P open; P N ſhews part of the broken nerve, Q R is part of the body faſten'd to the ſting, and placed in the thicker part of the caſe D C A, fig. 188. A B C, fig. 191, repreſents both the darts as they lie together cloſe againſt the ſheath[z]; yet one of them with its point a little before that of the other, to be ready (as I conceive) to be darted into the fleſh. And fig. 192. ſhews both the darts in part out of the ſheath; and one a little higher than the other, as if it were at work.

Fig. 193. repreſents one of the two arms wherewith Mr Leeuwenhoek thinks the bee makes her honeycombs, and are furniſh'd with three peculiar joints as at D, A, B. Fig. 194, is one of the ſcrapers placed on the fore part of the head, by which ſhe ſcrapes the wax from flowers. Fig. 195. is the wiper placed forward on the head,

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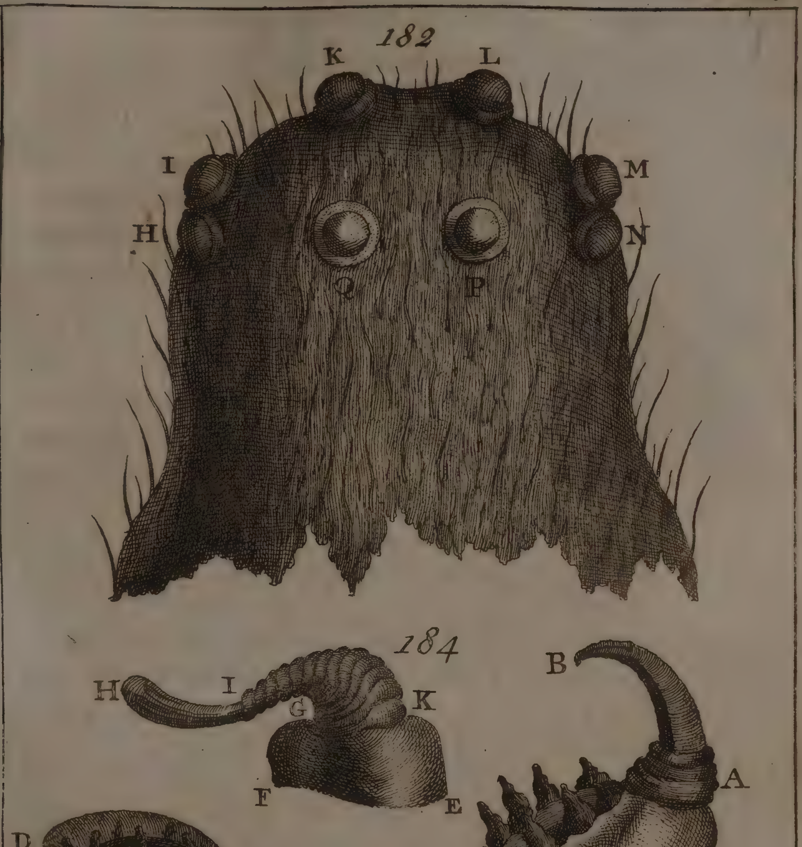
[y] Arc. Nat. Tom. iii. Epiſt. 133. Phil. Tranſ. No. 97.
[z] Derham's Phil. Theo. p. 240.

Pl. 36.



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Bowles sc.

head, and with it ſhe wipes the honey off the flowers; all which inſtruments when the bee hath done working are ſkilfully ſheathed under her head. Fig. 196 repreſents the ſcraper of a wild bee.

When the darts are ſtruck deep in the fleſh, if the wounded perſon ſtarts before the bee can diſengage them, ſhe leaves her ſting behind in the wound; but if he has patience to wait until ſhe withdraws the ſpears into their ſcabbard, the wound becomes much leſs painful.

If you divide a bee, eſpecially an humble bee, [a] near the neck, you will ſee the heart beat moſt lively, which is a white pulſing particle.

Within the yellow pluſh or fur of humble bees you may frequently find a ſmall whitiſh very nimble animal, [b] not much unlike the ſhape and form of a cheeſe mite.

The way to view a bee's ſting with the microſcope, is to cut off the end of its tail, and then touching it with a pin or needle, it will thruſt out the ſting and darts, which may be ſnipt off with a pair of ſciſſars and kept for obſervation; or if you catch a bee in a leather glove, its ſting will be left therein, being unable to diſengage its hooks from leather: and when it is quite dead, which it will not be till after ſeveral hours, you may quite extract it with its darts and hooks; by ſqueezing the tail, pulling out the ſting [c], and preſſing it at the bottom you may likewiſe puſh up the darts; but without ſome practice this will be a little difficult.

The poiſonous juice may eaſily be found in the bag which contains it; and by letting the bee ſtrike its ſting upon ſome hard body, enough of the ſaid juice may be obtained to put upon a ſlip of glaſs, in order to view the ſalts floating therein at firſt, and afterwards ſhooting into cryſtals; or if you gently ſqueeze its tail, you may perceive a drop of this diaphanous liquor at the very end of the ſting, which if wiped off will be immediately renew'd.

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[a] Power's Micro. Obſ. p. 4. [b] Ibid p. 20. [c] Power's Micro. Obſ. p. 4.

The ſtings of ſcorpions may be examined in the like manner.

The poiſon of vipers has alſo been viewed by the microſcope, but for a deſcription of this I ſhall refer the reader to Dr. Mead's Eſſay on Poiſons.

Of animalcula in fluids.

THE microſcope hath diſcovered to us that the ſmalleſt of all living creatures, we have been able to trace, are the animalcula in fluids, which would for ever have remained inviſible, had it not been for the aſſiſtance of that inſtrument.

If pepper, paſte, vinegar, hay, ſtraw, graſs, oats, &c. or any other vegetable production be infuſed a few days in water, expoſed all that time to the open air, they will abound with inexpreſſible numbers of minute living creatures peculiar to themſelves, but of various forms and ſizes.

Whereof ſeveral of the ſame ſpecies of animalcula, are frequently to be met with in different infuſions, and even in waters, that have been expoſed, eſpecially in September, without any mixture; ſuch have been frequently found therein, as are found in the cavity of a cabbage leaf, or on the dipſacus[d], &c. and that certainly ſeveral of theſe are the ſame animals under different forms,

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[d] Phil. Tranſ. No. 284.

Pl. 37.

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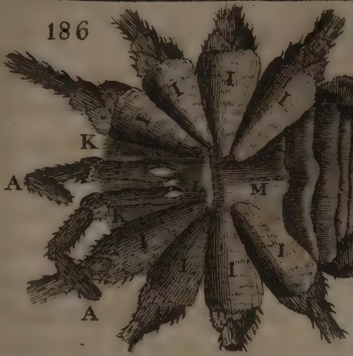

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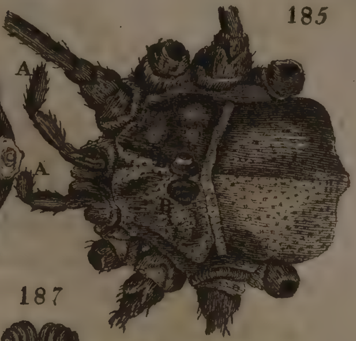

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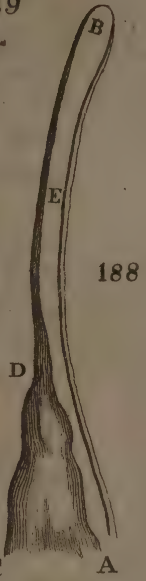

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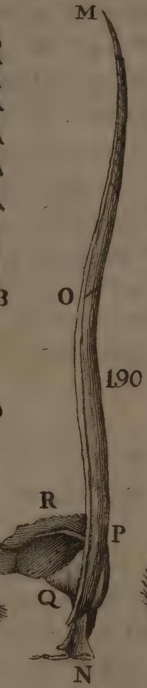

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forms, ſuch a regular proceſs being obſerved in them, and conſtant uniformity in their appearance, makes it probable that moſt of them are produced from the ſpawn of ſome inviſible volatile parents, and generated like gnats and ſeveral other ſorts of flies, which are bred and undergo ſeveral changes in the water before they take wing; that ſome of them originally may be water inſects, or really fiſh, ſmall enough to be raiſed in ſpawn with the vapours, and to fall down again in rain, and to grow and breed in water that is kept.

It has been thought that theſe minute flies, which hover every way in the air, when they find a fluid ſtored with convenient nouriſhment for their future offspring, reſort to it in ſwarms to lay their eggs, which being ſoon hatched, the animalcula produced therefrom ſwim about, and live happily, till grown to a certain ſize, change their forms, take wing and fly away.

If the infuſion is covered only with a fine lawn or muſlin, few animalcules will be found therein; but if it ſtands open it will be full of life in a few days: in the leaſt drop taken from the ſurface of ſuch infuſion, the microſcope will diſcover millions of living creatures.

Of eels, ſerpents, or little worm-like animalcula, found in vinegar and paſte.

IF vinegar be expoſed to the open air but a few days in hot weather, it will abound with eel-like animalcula, repreſented by fig. 197. two of which are ſeen at A, making equal undulations, ſometimes four or five are ſeen to move in the ſame manner; at B B B B, are ſhewn four others differently coiled, they coil and uncoil themſelves with a ſuprizing ſwiftneſs, at C is a repreſentation of one with a forked tail. Monſieur Joblot ſaw but one of theſe in 36 years obſervation: [e] however, the ſolar microſcope ſeldom fails of diſcovering ſome of them every obſervation. That marked D, although its mouth ſeems different from the reſt, is not ſo, but owing to its not being repreſented in the ſame poſition. They are to be applied to the microſcope by taking up a drop of the vinegar on a pin's head, and placing it upon a hollow glaſs ſlip or ſlider. When this drop begins to evaporate, their motion will be conſiderably retarded, at which time their mouths may be ſeen, and many other particulars may be obſerved in them.

Some people have imagined, that the ſharpneſs of the vinegar, is occaſioned by the eels ſtriking their pointed tails againſt the tongue and palate; but it is very certain that the soureſt vinegar hath none of thoſe eels, and that its pungency is intirely owing to the pointed figure of its ſalts, which float therein.

Animalcula in the ſhape of eels are often found in many infuſions but of a different ſize.

Dr. Power obſerves, that if vinegar, in which theſe eels abound, be but moderately heated, [f] they will all die, and ſink to the bottom. But cold does not hurt them, for after ſuch vinegar had been expos'd a whole night to the ſevereſt froſt, and was frozen and thawed, and frozen again, and ſo ſeveral times over, they were as briſk as ever: he alſo tells us, that he put ſome vinegar full of theſe eels into an eſſence glaſs, and poured thereon about the ſame quantity of oil, which floating on the vinegar, all the eels would conſtantly creep up into the oil, when the vinegar began to freeze, but when it thawed, they as conſtantly returned to it again.

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[e] Joblott's Obſ. p. 2. Imprimé à Paris. 1718. [f] Power's Micro. Obſ. p. 34.

To furniſh yourſelf with minute eels, always ready for the microſcope, boil a little flour and water, till it comes to the conſiſtence of ſuch paſte, as the book-binders and ſhoemakers uſe; expoſe it to the air in an open veſſel, and to prevent its hardening, or becoming mouldy on the ſurface, beat it well together whenever you find it tends that way; after a few days it will turn ſour, and then if it be examined with attention, you will find thouſands of thoſe eels on the ſurface thereof. To preſerve them all the year, you need only put a little water to them, if the paſte grows dry, or a ſupply of other paſte, always obſerving to keep the ſurface in a right condition, which will be eaſily done when it is once ſtored with theſe animalcula. Their continual motion will prevent any mouldineſs thereon.

Apply them to the microſcope upon a glaſs ſlip or ſlider, firſt putting on it a drop of water, taken up upon the head of a pin, for them to ſwim in, and if the paſte be thick, it muſt be diluted with a ſufficient quantity of water to diſentangle the eels, and render them diſtinctly viſible.

They are very entertaining objects, but more particularly ſo if examined by the ſolar microſcope, with which they may be magnified to an inch or more in diameter. The internal motion of their bowels may be very plainly ſeen, and their mouths open to a conſiderable width.

Of animalcula in ſeveral cold infuſions of whole pepper.

B, D, K, H, O, R, L, fig. 198. exhibits the firſt ſort of them, each having ſeveral little ſpots more tranſparent than the reſt of their body. The regularity of the figure, under which theſe animalcula generally appear, and the rapidity of their motion, prevents us from diſcovering on what part of their body their head is placed, but after a little time we are enabled to do it, although they continue in motion; for when the drop of water in which they ſwim, is grown thick by the inſenſible evaporation of its ſubtle parts, it gradually retards the motion of theſe minute fiſh; and affords us ſufficient time to obſerve many things, that will teach us to admire the creator's wiſdom, even in the ſmalleſt part of theſe minute creatures.

You may then perceive that as two of theſe animalcula are advancing forward, one moving along the line from A to B, and the other from C to D, in turning about the firſt follows the dotted line B E, and the ſecond moves from D to F.

You may alſo frequently ſee that of two of theſe animalcula, one of them will run as it were along the line G H, and the other over that of I K, leaving a ſmall ſpace between them, yet too little for a third L, to find a paſſage, which thus incloſed between them, ruſhes forwards to ſave himſelf in the direction of the dotted arch towards M. Others after having moved along a ſtraight line, as H G to O, turn about ſo ſwift upon a point at O, which is their head, that their oval figure appears almoſt circular, after which they launch out with an extremely ſwift motion towards P. Others alſo having run along a line as Q R, and as it were turning upon their own center at R, deſcribe ſeveral circles, then ſhoot forwards with an extraordinary ſwiftneſs along the line S T.

Fig. 199. repreſents another ſort of animalcula, whoſe head is adorned with hairs, and motion generally circular, called copple crown [g]. A third ſort repreſented at fig. 200. called a ſilver bag-pipe [h]. A fourth ſort is a kind of water ſpider, with its mouth open, as at fig. 201. Two of them are repreſented at fig. 202. conjoined and turning upon their common center. Fig. 203. ſhews two more of them alſo coupled as they ſwim in a ſtraight line. Another ſort is repreſented at fig. 204. in ſome meaſure reſembling a weaver's ſhuttle; its hinder part is tufted with hairs, which aſſiſt him in ſwimming. Fig. 205. exhibits a ſwarm of exceedingly minute inſects of different ſizes and ſhapes, which ſerve for nouriſhment to the larger ſorts.

Of white pepper.

INfuſions made of whole white pepper, produce finer animalcula than the foregoing, but not in ſo ſhort a time. The large bag-pipe of this infuſion advances and recedes by turns, as it ſwims before the microſcope; and juſt before the water is totally dried, a great number of eggs may be ſeen within them, and in the next moment they will all be dried up, and appear like a confuſed maſs.

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[g] Joblott's Obſ. p. 14.

[h] Theſe names were given to the animalcula of the ſeveral infuſions, by Monſ. Joblott, who endeavour'd to call them after the common names of things and animals, to which theſe animalcula bore ſome reſemblance; which reſemblances, I apprehend, in ſome caſes aroſe from the lively imagination and haſty determination of Mr. Joblott.

Of long pepper.

LONG pepper put whole into common water, produces animalcula no leſs ſuprizing than the two foregoing; in this is ſometimes found an animalcule ſomewhat like a caterpillar; and a different ſort of eels from thoſe found in vinegar and paſte, being thicker and ſhorter than they, but do not live near ſo long.

On repeating theſe experiments at different ſeaſons in the year, and in different years, other ſorts will be found not here repreſented.

Take common black pepper groſly pounded, and put it into a glaſs veſſel, as much as will cover the bottom thereof, about half an inch thick, on which pour about three or four times that depth of rain or river-water; ſhake and ſtir the pepper and water well together at firſt, but afterwards not at all, and expoſe the veſſel to the air uncover'd; in a few days a little ſkin may be ſeen on the ſurface of the water, which, examined by the microſcope, will be found to contain millions of animalcula, at firſt ſcarce diſcernable, but continually increaſing in bulk, till they arrive at their full ſize. Their numbers too increaſe prodigiouſly, till at laſt the whole ſurface of the fluid ſeems alive.

This experiment will ſucceed in winter, if the water is not frozen.

The animalcula repreſented by fig. 206. are very common, and are deſcribed by Mr. Leeuwenhoek, who hath ſeen the tails of ſome of them nine or ten times longer than their bodies,[1] which are about one third of an hair's breadth, but in general they are four or five times as long. In moving they commonly twitch up their tail into a ſcrew-like form, as at b, fig. 206. and this ſpring is ſo ſtrong, that when the tail is entangled, as it frequently is by the extremity, they bring back their whole bodies by the jerk and convolution of the tail, which quickly returns to its firſt ſtraitneſs. When they lie ſtill, they thruſt out and pull back again a bearded tongue, and a current conſtantly runs towards them, occaſioned probably by the motions of ſome fins or legs too fine to be diſcerned.

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[1] Phil. Tranſ. No. 284.

Thoſe animalcula exhibited by fig. 207. abound in all waters, and are largeſt of all; their length is about an hair's breadth, and three or four times more than their own [k]; they are very thin and tranſparent, and turn themſelves very quick, ſhewing both back and belly; their edges are adorn'd with a great number of minute feet ſeen chiefly at the two extremities; at one end there is a kind of bruſh reſembling a tail; they are ſwift in motion, and by their turns, returns, and ſudden ſtops, ſeem to be continually hunting for prey. a repreſents one of them on its back; b one on its belly; at c and d, is ſeen how they often appear in other poſitions.

There is generally another ſort of an oval ſhape, as at fig. 208. a b c, lengthening and ſhortening themſelves as occaſion requires, and ſometimes two of them may be ſeen conjoined, as at a.

Another ſort are a kind of capillary eels, they wave their bodies but little, move equably and ſlow, and ſwim as well backwards as forwards. See fig. 209.

Several kinds of mixtures put amongſt them, while they are before the microſcope, produce different effects. The ſmalleſt drop of ſpirit of vitriol, upon the point of a pin, being put to them, they immediately tumble down dead; diſſolved ſalts kill them; but with this difference,

inſtead

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[k] Phil. Tranſ. No. 284.

inſtead of being flat, as in the former caſe, they ſhrink into oval forms. Tincture of ſalt of tartar throws them into convulſive motions, after which they ſoon grow languid and die, without changing their ſhape. Ink kills them, and ſo does freſh blood, urine, ſpittle, and diſſolved ſugar [1].

There is alſo another ſort of animalcule, frequently found in this infuſion, of a ſpherical figure, only pointed like a pear, as at fig. 210. in which are a vaſt number of dark ſpots, in a confuſed agitation; they chiefly turn as it were upon a center, firſt one way, and then the contrary, ſometimes they take a large circuit, but always with their pointed end foremoſt.

Another ſort repreſented at fig. 211. is alſo found in great numbers; they move briſkly, are very active, contracting, and dilating as they ſwim along; they have ſeveral feet in their fore parts very viſible; when the drop of water is almoſt evaporated, they ſhrink up into a globular form, then their feet ſtanding out, may be ſeen to move nimbly; a, ſhews them at their length, and b when contracted.

Fig. 212. repreſents another animalculum, not uncommon amongſt the reſt; its motion very nimble, always keeping its ſharp extremity foremoſt; ſome are clear and ribb'd from the point to the thick extremity, others tranſparent only at the fore part, as at a and b.

The water which drains from dunghills, and is of a brown colour, is generally ſo prodigiouſly ſtored with various ſorts of animalcula, that it muſt be diluted with water before they can be ſufficiently ſeparated, to diſtinguiſh their different kinds; one particular ſort is found amongſt theſe, which is very rarely to be met with elſewhere, and are ſhewn at fig. 213. their middle part dark, and beſet with hairs, but both ends tranſparent, their tails tapering with a long ſprig at the extremity thereof, their motion ſlow and waddling.

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[1] Ibid. No. 203.

Of animalcula in a cold infuſion of ſenna.

ABout the middle of July, as much as could be taken up with two or three fingers of the leaves, ſtalks, and branches of ſenna, was put into cold water, and in about eight days, the ſurface thereof was ſtored with extremely minute longiſh bodies, ſeparate from each other, but without motion. The corpuſcles repreſented at fig. 214. were thought to be nothing elſe but pieces of the bark from the branches of the ſenna; but in about eight days after, they all diſappeared, and a ſurprizing number of worm-like animalcula ſucceeded them, but leſs than the firſt, being alive, and ſwimming a little below the ſurface of the water; one of theſe worms is ſeen at fig. 215. Its head round at I, its body compoſed of eleven ringlets, the loweſt extremity of which ends ſometimes in a plain perpendicular to its body. At other times with three round protuberances, as at M.

Through the ſkin there appears a very white fibre, branching as it were from each ſide of the tail, in a ſtrait line towards the head, where they unite in an arch, as at N, fig. 216. This fibre extends and contracts itſelf alternately, by which means the ringlets are drawn nearer to, or puſhed farther from each other. Part of the water being evaporated by its ſtanding ſeveral days, a little freſh water was poured thereon, which cauſed the ſkin that ſwam on the ſurface of the infuſion to ſink to the bottom of the veſſel; the infuſion was thereby refined, and more tranſparent than it was before, which occaſioned the diſcovery of two new ſorts of animalcula, and this in the leaſt drop that could be applied to the microſcope, D, and E F, fig. 217. are their repreſentatives. The largeſt of them reſembles the ſilver bag-pipe, each having crooked heads, as at F; they have alſo two motions, one ſtrait, and the other circular, ſlow enough to be eaſily obſerved.

Another kind of fiſh-like animulcula reſembling a carp, is ſhewn at fig. 218. its motion was wriggling as the dotted line a b c d.

In January a great number of another ſort were found in this infuſion of Senna, which ballance themſelves from right to left as they ſwim directly forwards. Another time, after repleniſhing the water, other minute animalcules that do not ballance themſelves were found therein, and the ſame day others alſo ſo exceeding ſmall that their form could not be diſcerned. A few days another ſort ſhaped like fig. 219. its head terminated almoſt in a point. After this infuſion had ſtood a whole year, another worm-like animalcule was found therein, repreſented at fig. 220. whereof A was its mouth, which was round; from whence iſſued three fibres to its forked tail B B, two other ſorts, as repreſented by K L, fig. 121. were alſo ſeen in this infuſion.

Of the water found in oyſters.

A Dozen of oyſters being opened, all their liquor was put in a clean drinking glaſs, which in the ſpace of two hours appeared to be upon the fret, and of a fine pearl colour, and its ſmell like that of the ſea; on applying ſome of this liquor to the microſcope after it had ſtood four days, a great number of minute tranſparent oyſters,[m] in rapid motion were obſerved therein. a b c d, fig. 222. repreſents one of them, of which a is the head, their ſhape altered as they placed themſelves in different poſitions before the eye, their motion was ſometimes direct, at others circular. The fifth and ſixth day ſome of them ſeemed to be dead; but, on continuing to obſerve them, were afterwards found to move with a prodigious ſwiftneſs, one going one way, another the contrary; often rubbing and ſtopping againſt each other; then being diſturbed by others ruſhing ſtrongly againſt them, altered the ſtate of their rencounter, and directed themſelves to another place; they ſtretch out and ſhorten themſelves conſiderably, and are often ſeen coupled as at a and c, fig. 223. and fig. 224. Moving together from a towards b, and from c towards d, they turn much ſlower than thoſe in pepper-water, and perform their circular motion much as they do, turning ſometimes on their own center, and ſometimes on a point near the extremity of their head. This liquor being obſerved near eight days, no other animals than thoſe of the ſame figure could be found therein.

In freſh oyſter liquor diluted with common water, were found animalcules with two moving horns in each of their heads, which formed a kind of creſcent as at e, in others as at d, fig. 225. but the horns are ſo tranſparent, that they muſt be viewed attentively, and that for ſome time before they can be diſcovered.

On putting the liquor of ſix or ſeven oyſters into a glaſs veſſel one day at noon, the next day at ſeven a quantity of theſe minute oyſters were found ſwimming therein, although the veſſel was ſtopped: whence it ſeems not improbable, but that theſe animals were produced

from

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[m] Joblott's Obſerv. p. 20.

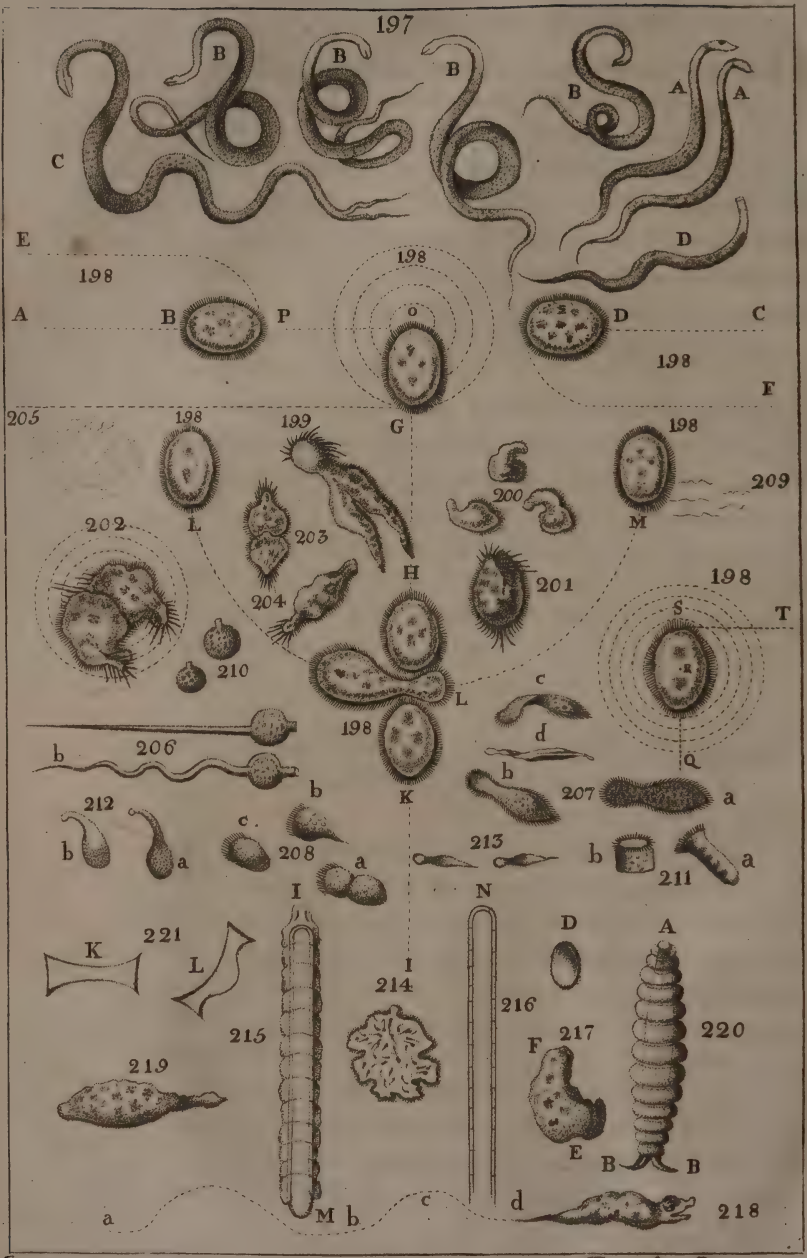
from the eggs of the oyſters themſelves, and that they do not proceed from other animals that either fly or float in the air. Six days after two different ſorts of new animalcula appeared in the ſame liquor; the firſt are repreſented at fig. 226. it ſtretches itſelf out and ſhortens itſelf alternately. The ſecond ſort is ſeen at fig. 227. which moved ſo ſlow that the following particulars were obſerved; it had four ſhort legs near its head, and five longer behind. In the ſame liquor was alſo found another ſort repreſented at 228.

In other freſh oyſter liquor were alſo found different animalcules, as repreſented at i, l, m, n, o, p, q, fig. 229. m exhibits a worm with a ſharp head and round tail. Thoſe at n and o ſhew two of the ſame worms joined together, the ſtrongeſt dragging along the weakeſt. At p is ſeen one of another figure, and at q are two ſmaller, holding each other by the beak and ſwimming in company.

Of an infuſion of pinks made in common water both cold and hot.

SOME pinks, not quite blown, being ſteeped in cold water, produced living animalcules, which upon examination with the microſcope were found to be of the ſhape repreſented by fig. 230. On the ſixth day appeared a larger ſort, but fewer, being very tranſparent, and ſtrewed with little ſpots, fig. 231. The eighth day the larger ſort appeared finer and longer than before, and moved after a different manner; in fifteen days the ſurface of the liquor was covered with little white worms, ſomewhat below which was a prodigious number of minute animalcules. The twenty-eighth day a large

Pl. 38.



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worm ſhewed itſelf under the form of fig. 232. The forty-eighth ſome eels, like thoſe in vinegar. The fiftieth day a little white worm was taken upon the ſurface of this water [n], its body ſo tranſparent, that ſeveral little white fibres were diſcovered therein; the two middlemoſt of which being a little ſeparated, and proceeding from the extremity of the body, run parallel to each other, and are united by an arch near the head: it hath two black eyes, and two hooks in the fore part of its head, as repreſented at fig. 233. At G of the ſame fig. is ſeen another of a curious form, found alſo in this infuſion.

Some pinks being infuſed in boiling water, which in eleven days time ſwarmed with animalcules, but very ſmall, and on the fifteenth day were not to be found, only ſome worms might be ſeen on the ſurface thereof with the naked eye.

Of a cold infuſion made of a noſegay, compoſed of pinks, roſes, and jeſſamin.

THIS infuſion was made the eleventh of May, and the noſegay cut into pieces for the better placing it in the veſſel, and in about three or four days a great number of minute animalcules, and ſome larger ones, were found therein; their figures, colour and motions are ſo various, that it would be a taſk too long to undertake a deſcription thereof. Nevertheleſs I cannot paſs over in ſilence an animalcule that was found in this liquor on the beginning of September. It conſiſted of three diſtinct parts, fig. 234. The firſt part A is its head, which advances and retires by jerks. B, the trunk of its body, and C its tail, it is of a tranſparent white, and often draws its tail in, at the end of which are two black hairs D D.

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[n] Joblott's Obſerv. p. 28.

Of an infuſion of blue-bottles.

THE ſtalks of a large noſegay of blue-bottles with ſome of the flowers, were put into cold water on the ſecond day of June, and at the ſame time ſome of the flowers by themſelves were put into a glaſs of water; in twelve hours time the microſcope diſcovered ſeveral animalcules of the form of fig. 235. in a ſmall drop of this liquor. And the next evening four other ſorts, very tranſparent, of an oval figure, unequal in ſize, and different in their motion. The fifth of the ſame month, another ſort of the ſhape of fig. 236. appeared therein; and on the ſixth a new ſort, A B C, Fig. 237. with an oval head and a tail, which terminated in a point, being five or ſix times longer than its body. On the ſeventh day, one of theſe laſt was obſerved to drag after it a bunch of the ſediment of the infuſion, which ſunk to the bottom of the concave, upon which the drop of liquor was placed for obſervation. It is very pleaſant to behold ſo ſmall an animal endeavouring to pull this bunch about, which he is ſcarce able to move, as at I, drawing himſelf back, and wriggling its tail, as at M. Sometimes five or ſix of theſe animalcules may be ſeen faſtened by the tail, to a great bunch of this ſediment, that ſticks to the bottom of the object carrying glaſs, drawing themſelves nearer to, and retiring farther from it by turns. During this exerciſe, they change their firſt figure, and recover it again alternately; and as their tail is naturally ſtrait, as at I, they endeavour to drag the lump after them in a right line.

It is remarkable, that extremely hot weather kills them, and in five or ſix days they are ſucceeded by others.

We have no reaſon to doubt, but theſe minute animalcules are furniſhed with eyes, for two of the ſame figure are often ſeen to approach each other without touching, and then turning, with a prodigious ſwiftneſs about their own center.

Another ſort is ſometimes found in this infuſion, whoſe extremities are terminated by two plane ſurfaces, parallel to each other, as at fig. 238.

An infuſion of tea.

HAVING put into the tea-pot as much tea, and a ſufficient quantity of boiling water, as would make ſix large cups, on the fifteenth of July; the tea-leaves which remained after the hot infuſion, were put into a large glaſs jar, filled with ſpring-water, and expoſed to the open air for about ten days; after which, in the leaſt drop that could be taken up, when applied to the microſcope, were found a ſwarm ° of exceedingly minute animalcules, of a round figure, moving ſlowly. Some days after they were fewer in number, but increaſed in ſize, clearer, much more diſtinct, and of an oval figure, as at fig. 239. the circumference of their body appeared black, but all the reſt perfectly white and tranſparent, and now ſwam with a ſurprizing ſwiftneſs. Their bodies were of ſo delicate a conſiſtence, as that their natural figure was preſerved for the ſpace of two or three minutes after they were dead.

The

° Joblott's Obſerv. p. 34.

The twenty-third of September, three other ſorts of more minute animalcules were found in this liquor, and ſome of the eel-kind alſo.

An infuſion of raſberry-ſtalks.

THIS infuſion is one of them which does not cauſe a diſagreeable ſmell, nevertheleſs it produces in about twenty-four hours time, the fineſt [p] animalcules that are to be met with in fluids, and in as great numbers. Their repreſentation is at o o, Fig. 240. they are at firſt very white and tranſparent, but more ſo in ſome place than in others, with little marks upon them, and at length this whiteneſs changes into a tranſparent yellow colour. They may be ſeen ſtretching out and ſhortening themſelves from oval to round, by means of obſtacles which they find in their way. They are often ſeen to hold each other by the beak, and in that poſture they move exceeding faſt, without quitting their hold, as at P. Another ſort of animalcule was found in this infuſion, of the ſhape repreſented at Q; between the middle of its body, and the head, was a tranſparent ſubſtance, regularly beating, but ſo quick, that the ſhape of it could not be diſcerned.

Infuſions of fennel, ſage, melon, ſour grapes, ſtalks, and leaves of marigolds.

FENNEL, with its large and ſmall ſtalks, was put into cold water to infuſe, Auguſt eleventh and on the thirteenth following, in the ſmalleſt drop that could poſſibly be taken up, and placed upon the object carrying glaſs, might be ſeen a ſwarm of an almoſt innumerable quantity of little animals, repreſented at fig. 241. amongſt which were others of a round figure, and about five or ſix times longer.

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[p] Joblott's Obſerv. p. 35.

The twenty-ſecond of Auguſt, ſome ſage leaves were infuſed in cold water, and retained their natural ſmell all the time of the infuſion, which was about twelve days; nothing was ſeen in this liquor but ſome little animalcules [q] that appeared no bigger when magnified, than a grain of millet does to the naked eye; and an infinite number much ſmaller, that when magnified, appeared no bigger than the ſmalleſt dot that can be made upon paper, with the fineſt pen, and a little below the ſurface of the liquor, was found three very ſmall but white worms.

The twenty-eighth of September, in a drop of this infuſion, was found two ſorts of minute animalcules, repreſented at fig. 242.

The twenty-ſecond of Auguſt, ſome barberries were put into cold water, which produced animalcula of the ſhape of T, fig. 243. in twenty-four hours time.

The twenty-fifth of the ſame month, a bit of the rind of a melon, with a little of the pulp, and a few of its ſeeds were put into cold water; the next morning appeared ſome fine tranſparent animalcules, whoſe form is ſhewn at V, fig. 243. Many little white longiſh bodies were alſo found therein, whoſe figures are ſeen at X; and other leſs bodies marked T, without any ſenſible motion.

Some four grapes were alſo infuſed in cold water, on the fourteenth of Auguſt, and on the twentieth, a great number of animalcules appeared therein, but ſo exceedingly minute, that their ſhape could not be diſtinguiſhed; on the twenty-fifth two ſorts preſented themſelves, one as ſmall as the laſt; the other at Y, fig. 244. The fourth of September theſe little animalcula were exceedingly multiplied and increaſed in ſize, ſome of them were joined together in the form of a figure of 8, as at P, fig. 244. and moved ſometimes circular and ſometimes in a right line; on the eighth of September were found upon the cruſt, which ſwam upon this infuſion, ſome minute worms, and alſo in a drop of the liquor a conſiderable quantity of other eel-like animalcula.

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[q] Joblott's Obſ. p. 37.

On the 25th of Auguſt, ſome of the ſtalks and leaves of marigolds, were put to ſteep in cold water, and eight days after there was three ſorts of animalcula found therein; the firſt is repreſented at Z, fig. 245. the ſecond at R, of the ſame figure; and the laſt, for which there was no room in this plate, were of the eel-kind, different from thoſe in vinegar, and different alſo from thoſe in paſte.

Firſt infuſion of new hay in cold water.

THIS infuſion ſtood but twenty-four hours before it was filled with life, and at the end of five or ſix days, in the moſt minute drop of this water, five or ſix ſorts of living animalcula were diſcoverable; different in colour, ſize, figure, and motion.

The ſmell of this infuſion is very ſtrong in hot weather, but decays as the infuſion grows old; animalcules are very rarely to be met with in any other infuſion that are larger, finer, more tranſparent, or that live ſo long as thoſe found in this.

The ſecond infuſion of new hay.

THE 4th of October ſome new hay being put into cold water in two different veſſels, one of which was ſtopped cloſe with a piece of vellum, made very wet, and the other left open: two days after, three ſorts of animalcula were diſcover'd in each infuſion, and alſo a ſufficient quantity of them: this experiment is a proof, that thoſe animalcules were produced from eggs, which had been depoſited by their parent [s] animals upon the hay, and alſo that they were not wafted thither in the air.

The 10th of the ſame month, more of theſe animalcula were found in one drop of that infuſion, which had been covered, than could be ſeen in the like quantity not covered.

The third experiment made upon the ſame hay.

THE 13th of October ſome of the ſame new hay was boiled in common water, above a quarter of an hour, and an equal quantity of it put into two veſſels, nearly of the ſame ſize, one of which was immediately cover'd, even before it was cold, and the other left open, in which was found ſome animalcula, at the end of a few days, and not one in the infuſion, which had been covered; [t] after which great care was taken to keep it cloſe for a conſiderable time, to try if there were any living animalcula therein, but none could be found, at length it was left open, and in a few days, ſome animalcules were found therein, which determined that theſe animals proceeded from the eggs of their parent animals, wafted thither in the air, ſince thoſe which had been brought there in the hay, were totally deſtroy'd by its being boiled in water.

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[s] Joblott's Obſ. p. 39. [t] Ibid. p. 40.

A compoſition of ſeveral infuſions mixed together in one veſſel.

TAKE equal parts of an infuſion of ſenna, of raſberry ſtalks, and of hay, &c. mix theſe all together, and half an hour afterwards take as uſual a ſmall drop of this mixture, which being put upon the object carrying glaſs, and placed before the microſcope, will give you the pleaſure of ſeeing in this little drop, the animalcula of all the infuſions you have mix'd together. [u] And here it is proper to take notice, that all theſe different animalcula cannot ſubſiſt long in this mixture, each being deſirous to remain in its firſt infuſion, therefore all ſorts of infuſions are not proper to afford the pleaſure of this ſight, for they ought to contain in them ſomething upon which the animals can ſubſiſt.

An infuſion of rhubarb.

RHubarb is a purgative drug, and muſt be a long time infuſed in water before any animalcula can be found therein, or any diſagreeable ſmell, for in about five weeks there was found only one ſort of animalcula, which does not merit a particular deſcription; we ſhall only ſay that the mixture of a drop of this infuſion, with as much of that of ſenna, does not deſtroy the animalcula in either; and that at the end of fiteen days the animalcula in the infuſion of rhubarb [x] were all dead.

Of

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[u] Joblott's Obſ. p. 40. [x] Ibid p. 48.

Of an infuſion of muſhrooms.

A Large muſhroom being infuſed in cold water, produced from one day to another an aſtoniſhing multitude of infinitely ſmall animalcules, of a round figure, which appear'd in a microſcope that magnified twenty-five thouſand times, of the ſame ſize that a grain of rape-ſeed does to the naked eye [y].

The third day ſome of a larger ſize were found therein, with a crooked neck, and very tranſparent; ſoon after a third ſort was diſcovered of an oval figure, and fluttering motion.

Of the little flowers of different colours that are found in meadows.

IF ſome of theſe flowers, when they are juſt blown, be put into cold water, in a few days a particular ſort of animalcule will be found therein, reſembling the ſole of a ſhoe, one of which is repreſented at fig. 246. Its motion is ſlow, and its head directly under the letter A; it inclines itſelf towards B and C, ſtretching itſelf out, and contracting alternately; ſometimes all its body appears as round as a bowl, at which time the ſurface thereof is uneven: their body is marked with longiſh ſpots, and is ſo tranſparent, that all their inteſtines, and the periſtaltic motion may be diſtinguiſhed, which are a very agreeable ſight. [z] Theſe larger ſort appear at the beginning of the infuſion, but at the end of fifteen days a great number of thoſe repreſented at fig. 247. were ſeen therein, which is contrary to what generally happens in other infuſions, where the ſmalleſt appear firſt.

Of

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[y] Joblott's Obſ. p. 48. [z] Ibid p. 49.

Of an infuſion of ſweet baſil, which ſmells like citron.

THREE ſorts of animalcules ſhew themſelves in a few days after ſweet baſil hath been infuſed in common water; the firſt are ſeen at A, fig. 248. the ſecond at B, and thoſe of the third ſort almoſt like that repreſented at C. This laſt ſwims in a ſpiral line, folding and unfolding its body every way.

A, B, C, fig. 249. repreſents the animalcules found in the infuſion of new hay, the colour of one, and figure of the other, was the occaſion of calling one golden, and the other ſilver bag-pipe. That ſort repreſented at D E, are called clubs; the head whereof is ſeen at D. Theſe animalcules extend and contract, twiſt and untwiſt themſelves ſeveral ways.

Infuſion of blue-bottles.

FIG 250. repreſents a new ſort of animalcula found in this infuſion of blue-bottles. A ſhews the head, B its tail, C D its breadth, which ſeems divided throughout its whole length by a curved line, drawn from B towards A; that part of the body marked C, ſeem'd to be filled with ſeveral little globules, leſs tranſparent on this ſide, than on that marked D; the neck of this animal, which is very long, ſhortens itſelf from time to time, as does alſo the hinder part, marked B [a]. It ſwims extraordinary ſlow, and does not live upon the object-carrying glaſs above five or ſix minutes, but two of theſe were diſcovered in five or ſix drops, and the ſecond,

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[a] Joblott's Obſ. p. 51.

cond, fig. 251. was ſomething different from the firſt, for its body B C was furniſhed with little globules, that render'd it leſs tranſparent than the firſt was, at A B and C D.

Infuſion of old hay.

IN this infuſion were two ſorts of animalcules that merit a particular deſcription. The leaſt is ſeen at fig. 252. it was of a tranſparent white; A its head, B its forked tail, with which it puſhes itſelf forward; and it ſwims ſo ſteadily that no particular motion of its body can be diſcerned.

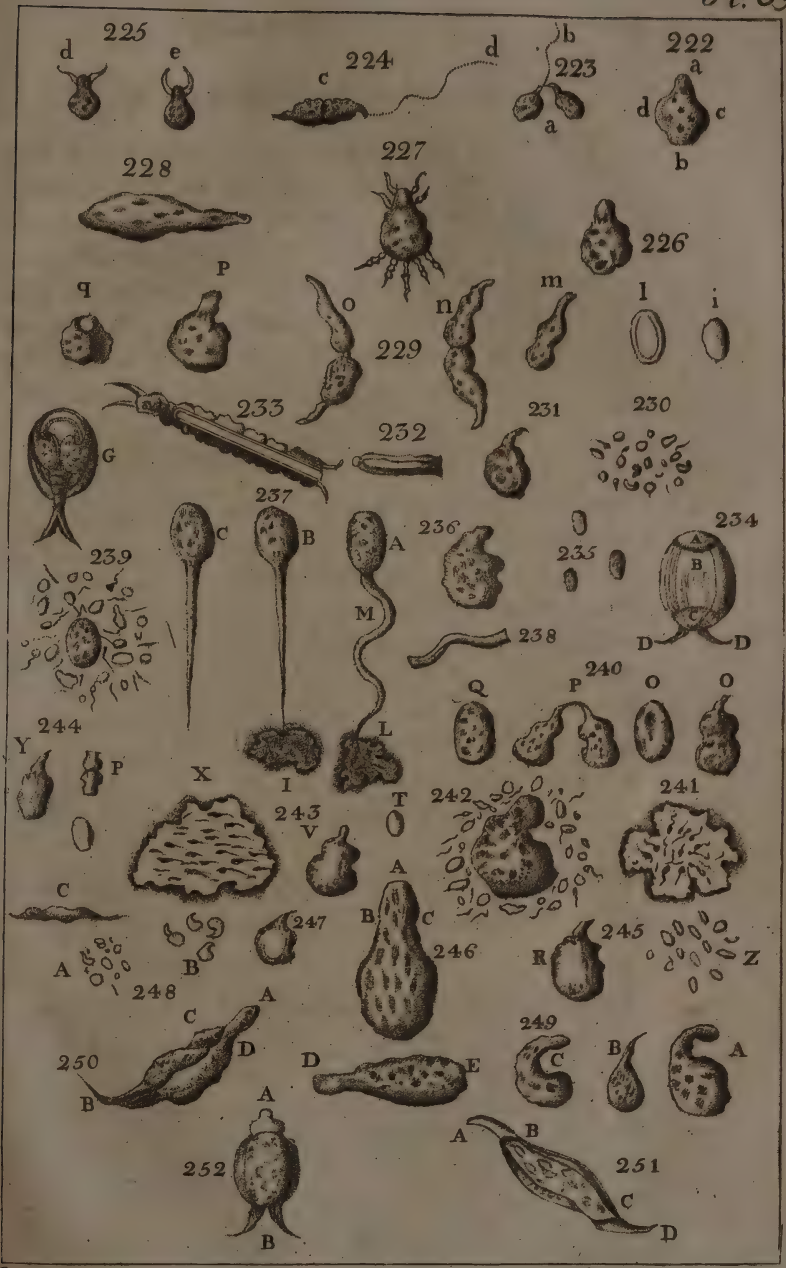
The ſecond ſort are more extraordinary and ſurpriſing, as well in ſize as other circumſtances; two of them are repreſented at fig. 253 and 254. marked A, C, D, B, and A C E F B; A ſhews the head, B its forked tail, C its heart, which may be ſeen in a regular motion, and D its inteſtines. It is called an aquatic caterpillar; there are two different colours of them, one of a tranſparent white, the other of a pale yellow. In moving on the object-carrying glaſs, they firſt fix the points B, and then extending their body as much as poſſible, reſt the fore part upon another place, and draw up the hinder part, and then again fix the point B as before, and ſo on; they alſo fix the points of their tail to the object-carrying glaſs, and ſtretch out and retract themſelves by jerks, and ſometimes turn round about upon the point B, at other times they ſpring forwards with a ſudden jerk, and ſwim about for ſome time.

When they reſt themſelves, they commonly open their mouths very wide as at A, fig. 254. its lips alſo are furniſhed with hairs, as expreſſed in the figure, which move very quick; it is really ſurpriſing to ſee how haſtily they ſwallow down other ſmaller animalcula that happens to be within the reach of their mouths. At certain times all the hairs at the hinder part of their body which ſtand upright, are ſeen to lie down from E F to B. The circumference of the body ſeemed indented like the teeth of a ſaw, which upon a cloſer examination was diſcovered to be ringlets lying one over another, coming out with a ſurpriſing ſwiftneſs, and ſometimes even the nervous fibres were viſible, extending from head to tail, ſwelling and contracting alternately as they crawled along.

A mixture of the infuſions of hay and celery, does no hurt to either of the animalcula of the two liquors; but the leaſt drop of this mixture affords a very pleaſant proſpect to the ſpectator, who will in an inſtant diſcover variety of theſe fiſh-like animalcules of different ſorts, moving in all directions.

See alſo a deſign of another aquatic caterpillar at fig. 255. it was fiſhed out of an infuſion made of the ſtalks of a noſegay compoſed of pinks, jeſſamin, tuberoſe, and other flowers; this differs from the foregoing: firſt, in being longer; ſecond, that its tail marked I, is compoſed of three points inſtead of two; third, that it hath two little arms L M, one on each ſide its heart a; fourth, that its inteſtines marked b are without any viſible ſeparation; and laſtly, that neither ringlets, ſaw-like teeth, nervous fibres, nor hairs in the length of its tail could be diſcovered in this animalcule, but in all other reſpects it was the ſame as the foregoing caterpillar.

Pl. 39



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An infuſion of citron flowers.

IN Auguſt ſome of theſe flowers were put into cold water, in a few days three ſorts of animalcules were ſeen therein, which did not merit a figurative repreſentation. But ſome time after others appeared, called tortoiſe, one of which is repreſented at fig. 256. Its head, though large, is very ſhort, and adorned with two horns like thoſe of a deer: its body ſeemed to be covered with ſcales, its tail very long, and ſwift in motion.

Infuſion of anemony.

NAture is pleaſed to diverſify all her productions, and is ſurpriſingly admirable in all her works, by continuing to give us proofs thereof in this infuſion of anemony prepared after the ordinary manner with cold water, which at the end of eight days afforded a new animalcule, repreſented at fig. 257[b].

All the ſurface of its back is covered with a very fine maſk in form of a human face, perfectly well made, as appears in the figure. It hath three feet on each ſide, and a tail coming out from under the maſk.

Infuſions of three different portions of celery ſtalks and leaves, put ſeperately into different glaſſes.

ON the firſt of November ſome of the ſtalks of celery were broke into little pieces, and put into the firſt glaſs, and common water poured thereon, and alſo upon the green leaves in the ſecond glaſs, and in the third glaſs ſome pieces of the ſtalks with ſome of their leaves with water.

Seven

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[b] Joblott's Obſ. p. 57.

Seven days after theſe preparations, ſome animalcules were found in each of them, two ſorts in the firſt, and but one only ſort in both the other: but in about a month's time all the three infuſions contained ten different ſorts both in ſhape and ſize.

Thoſe of fig. 258. and 259. are the ſmalleſt; but in number they exceed all the other; when coupled they reſemble a figure of 8, as at a, fig. 259. Theſe alſo are called bag-pipes; they couple by the beak, which is a little crooked and ſharp, and notwithſtanding this coupling they ſwim very faſt, diving to the bottom of the drop of liquor which is placed upon the object carrying glaſs, and riſing up again to the top thereof alternately; they ſeparate from, and approach each other, without intermiſſion. Theſe bagpipe-like animalcules are not entirely alike; but there is in theſe, as in all other animals, different ſorts of them.

Some of them ſwim alone with a ſurpriſing rapidity, while others advance with a moderate ſwiftneſs, ſome go very ſlow, and others reſt quiet for a long time together; but the greater part of them are in a perpetual agitation; ſome of them are long, ſome ſhort, others as white as ſilver, ſome of a golden colour, and others brown.

It is a ſingular curioſity to obſerve what paſſes upon the ſurface and all around the circumference of a maſs of matter which hath formed itſelf into a very little bit of thin ſkin, ſo ſmall, that the beſt eyes are not able to ſee it without a microſcope: they are found by chance on the ſurface of the infuſion, and are generally faſtened to the end of the ſtalks. If a bit thereof be taken out with the point of a pin, and placed upon the object-carrying glaſs before the microſcope, there will be ſeen ſwarms of all theſe animalcules we have been ſpeaking of. There are ſuch great numbers of them moving with ſo much celerity, that it is troubleſome to turn the eye upon a ſight ſo new and ſurpriſing. In certain places thereof there are ſeen ſome differently coupled. Others alſo, that reſt themſelves, and keep the watch as ſoldiers do, which ſeem apprehenſive of being ſurpriſed; whilſt others go out a good way from the maſs as though they would make ſome diſcovery, then they return again as if they had ſomething to relate to thoſe which kept the watch, and this is ſeen all round the maſs.

In another drop, taken from another place of the ſame veſſel, has been often ſeen another new and curious ſight, viz. that ſort of animalcula which are long and flat, called ſoles, and are repreſented by A B C D, in fig. 260. The ſides of this animalcule are very ſharp; the head and all the reſt of its body is tranſparent, except a few brown ſpots which appear within. The different poſtures, and the variety of motions obſervable in theſe animalcula, cauſe more pleaſure in beholding them through a microſcope, and greater ſatisfaction than can poſſibly be imagined by reading the moſt particular deſcription of them.

In the glaſs where only the leaves were infuſed, there were amongſt others ſome animalcules like thoſe expreſſed at E, F, G, fig. 261. at one end of theſe figures may be ſeen a conſiderable opening which is their mouth, and appears ſometimes round as at F, and ſometimes ovaliſh as at E and G; at other times it is ſo firmly cloſed as not to be diſcovered. It ſwims by jolts, and ballancing from right to left, conducting itſelf in appearance by a circular motion of its head. It alſo changes its figure by folding, unfolding, and ſuddenly rolling itſelf up in the form of a ball, and then alternately ſtretching out again very quick into its natural ſtate.

There is another ſort of animalcula that appears to have neither head nor eyes, and are repreſented at H I K, fig. 262. their body ends in a long tranſparent tail, and motion generally very ſlow. They are frequently obſerved to have a bit of the ſkin (which is formed on the ſurface of the infuſion) ſticking to their tail as at L, ſometimes they drag it after them, at other times it happens to ſtick to the object-carrying glaſs, at which time they draw themſelves back on a ſudden towards it, and then ſtretch out again very ſlowly.

In the leaſt drop that could be taken up from the third glaſs, wherein the leaves, ſtalks, and roots were mixed, was ſuch an infinite number of thoſe little animalcula repreſented at fig. 258. that they could ſcarce find room enough to paſs between each other.

There was alſo a large oval animalcule, as at M N, fig. 263. its head could not be diſtinguiſhed.

In a ſecond infuſion of the leaves of celery was a new animalcule, repreſented at fig. 264. its head is ſeen at O, and is beſet with long hairs that move alternately, its motion is ſlow and figure uncertain, appearing ſometimes under the form of a bag-pipe, and at others, under that of a croſs.

Fig. 265. repreſents another ſort of animalcule of a ſpheroidical figure; another ſort at fig. 266. and others like fig. 267. this laſt moves with a ſurprizing velocity, and frequently turns itſelf upſide down.

Amongſt other infuſions of celery, was found an animalcule in the ſhape of a bottle, as at fig. 268. Fig. 269. exhibits another ſort of the bagpipe-like animalcules, two of which are ſeen at P, differently coupled from any of the foregoing.

Laſtly, at fig. 270. is repreſented a moſt extraordinary animalcule, almoſt round, its body covered with hairs, and motion circular.

Of infuſions of ſtraw and the ears of wheat.

IN the beginning of March, ſome wheaten ſtraw, and two ears of wheat were put into cold water, the ſecond whereof produced animalcules of the ſhape of fig. 269.

Others alſo were found therein, repreſented at fig. 271. its mouth is ſeen at A, the inſide of its body was filled with a quantity of little white and brown tranſparent corpuſcles.

A third ſort is repreſented at fig. 272. turning according to the order of the letters A B C, and moving ſlowly, its colour like that of unpoliſhed ſilver, ſtrewed with little brown ſpots. Its head is ſeen at A, tail at B, and back at C.

Another ſort of animalcule is ſeen therein of an oval form, and one called a golden bottle, repreſented at fig. 276. its mouth is ſometimes fixed to a round body, to which it ſtrongly adheres, as at fig. 273.

Another ſort called ſoles, contracting and ſtretching themſelves out as they ſwim along, which is very quick, are repreſented at fig. 274.

See alſo another ſort, at fig. 275. their mouth is at A, which is ſometimes extended to a great width. B C is the tail.

Fig. 277. repreſents an animalcule with a ſwan-like neck. A is its head, B its tail, and C its body. They are of two ſorts, one very tranſparent, and the inſide of the body of the other browniſh. Their inteſtines may be ſeen in motion.

The animalcules S and T, fig. 278. are thoſe which were before called water-ſpiders, or rather greedy guts, from the quantity of other minute animalcula they ſwallow.

That repreſented fig. 279. is the only one of its ſort found in the infuſion of wheaten ſtraw. Its figure is like a purſe, its mouth large, and here repreſented open; but when it ſtretches itſelf out for ſwimming, it is ſo neatly ſhut, as to encloſe its horns.

Fig. 280. exhibits an animalcule, called a little ſole; and at fig. 281. and 282. are two others that move extreamly ſlow, and are thouſand times ſmaller than an hair [c].

Fig. 283. repreſents a worm-like animalcule, compoſed of a great number of very ſmall ſpiral rings, whoſe extremities are terminated in very long, and exceeding fine points.

Of aquatic pomegranates.

THIS name of aquatic pomegranates, crowned and bearded, is given to the animalcula, which are repreſented by the figures 284, 285, 286, 287, 288, and 289. becauſe their ſhape in ſome meaſure reſembles that fruit [d]; they were found in a ſmall drop of an infuſion of wheaten ſtraw, and ſeen with a lens one eighth of an inch focus.

They appeared of a fine tranſparent amber colour, which therefore affords a curious ſight of their inteſtines; the ſeveral forms under which this animalcule appears, require a particular deſcription, which take as follows:

In fig. 284. under the letters A B C D, are ſhewn four little eminencies, adorned with hairs, which remain but a ſhort time in this ſituation, for that marked B joins A, and

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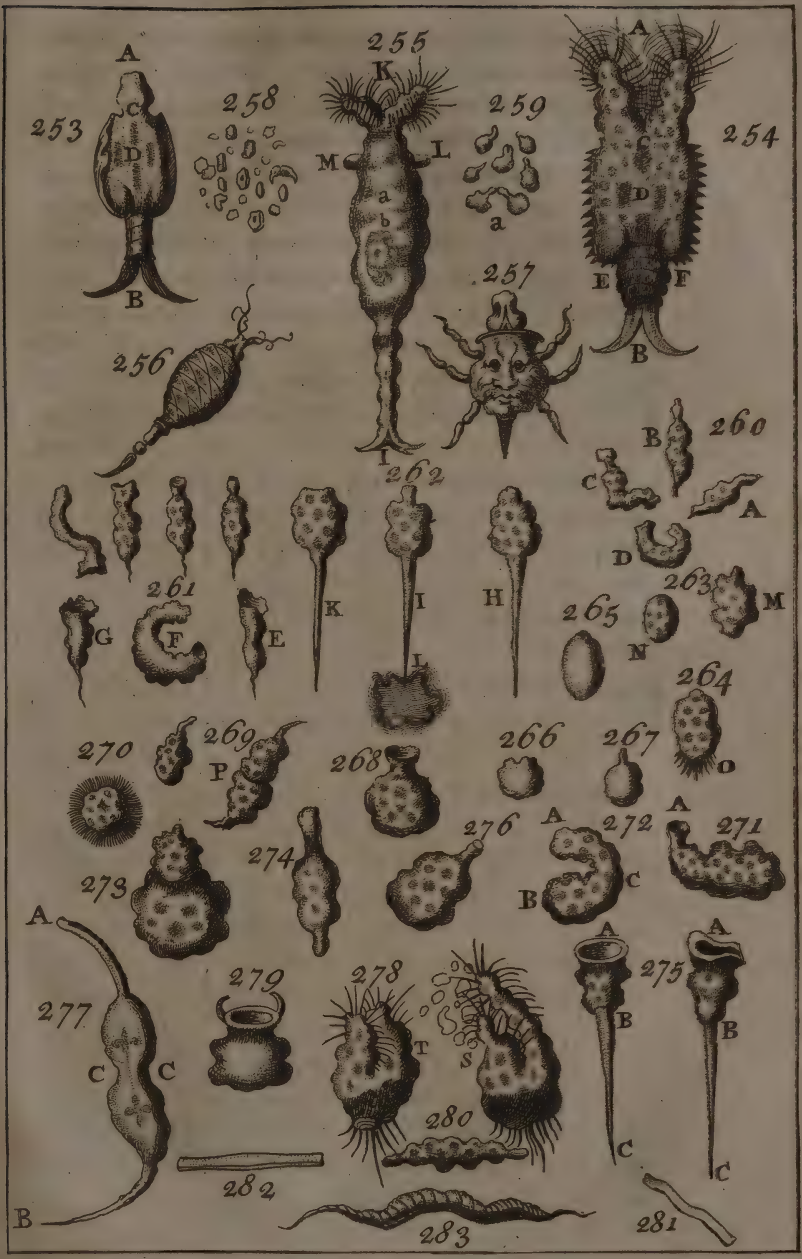
[c] Joblott's Obſ. p. 67.

[d] Joblott's Obſ. p. 68.

Pl. 40.



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and C unites with D ſo cloſely, that they then appear as at A D, fig. 285. Theſe increaſed eminencies, form the ſeparated lips of this animalcule, and the regular motion of the hairs with which they are adorned, obliges all minute bodies, at a ſmall diſtance from theſe lips, to enter into its mouth. Part of which is alſo as ſtrongly repelled, as it was greedily ſwallowed.

All the protuberances A, B, C, D, of fig. 284. or the two of fig. 285. contracting themſelves a little towards E, diſcover a ſort of crown, with four points, repreſented at fig. 286. which are preſently covered again with theſe eminencies, and then expoſed again, and ſo on.

In each of theſe figures, at E, is ſeen a regular pulſation, ſuppoſed to be its heart; it ſeems to be embraced by two lobes, that ſeparate and join alternately, which probably are the lungs; from theſe proceed two little ligaments at G, towards the inteſtines, whoſe periſtaltic motion is alſo very regular.

The tail of this animalcule appeared ſometimes round and cloſe, at other times open, when two little points, as at H, fig. 284. might be ſeen.

One of theſe animalcules had four of thoſe ſharp points, fig. 287. placed two on each ſide the anus; between which a long tail I L is protruded, and drawn in again with great ſwiftneſs: the end L, in ſome of theſe animalcules, appeared forked, as fig. 285. the tail can be entirely drawn into the body, at which time the rings that compoſe it, ſlide one over the other, and cauſe it to become opake.

Their eggs are frequently ſeen faſtened to their breech by ſmall threads; ſome of the females carry but one, as at M, fig. 289. others two, fig. 285. and ſome others ſix, fig. 286. but this is ſeldom, and then alſo they are ſmaller.

ler. They rub their eggs with their tail, which as it enters into, and goes out from the body, turns from one ſide to the other with a great deal of pliableneſs; thoſe eggs which are full, appear hanging down, and are very regular and bright, thoſe that are empty are ſeen quite flat, and of an oval form, and more tranſparent than the others, and although empty, their mothers carry them almoſt always faſtened to their breech, as at fig. 286. Two of theſe eggs were ſeen in the body of one of theſe animalcules, and appeared as at G G, fig. 288.

Theſe animalcules are a delightful object for the microſcope, particularly when they tumble over head and tail, becauſe they do it dextrouſly. Some turn themſelves circularly, as much on one ſide as the other, and about the point F, which is the center of gravity of their bodies.

Infuſion of the bark of an oak.

SOME of this bark being put into cold water, the fifteenth of December, and examined ſeveral times for the ſpace of a whole year, during which time the following animalcules were diſcovered. The firſt was called a tortoiſe with an umbelical tail, fig. 290. This inſect ſtretches out and contracts itſelf very eaſily, ſometimes aſſuming a round figure, which it does not retain above a moment; then opening its mouth to a ſurpriſing width, forms nearly the circumference of a circle; its lips are furniſhed with hairs, whoſe motion is very pleaſant, becauſe it obliges ſome of the adjacent little bodies, to precipitate into its ſtomach, where that which is fit for food remains, while the other is repelled with great velocity; its motion is very ſurpriſing and ſingular.

Fig. 291. is another ſort of animalcula with an umbelical tail, differing only from the former in having its mouth fixed, and tail without any ſeparation.

Fig. 292. repreſents another of the ſame ſort, altho' under a form ſomewhat different; the top of its head is double, and two prominencies appear thereon under the form of horns, which were intirely covered in the other.

That repreſented at fig. 293. is called a water-rat, its head well ſhaped, and lips adorned with long hairs.

Another ſort at fig. 294. is called a crab's claw, becauſe of its two crooked beaks, whoſe motion as well as that of its body is very ſlow, its body is adorned with a great number of ſhining globules.

Fig. 295. is called a club, its head large in proportion to its body, which ends in a point, the inſide of which is ſtrewed with little grains both tranſparent and opake.

That ſort exhibited by fig. 296. is called a ſilk-worm's bag, becauſe its body is compoſed of ſeveral rings and longitudinal fibres, the ſhape of its head is ſo nearly like that of the tail, that it can only be diſtinguiſhed by its ſwimming.

The animalcule, fig. 297. is called a ſpheroid, its head is ſeen at A, a little below which may be ſeen its heart regularly beating; and ſeveral round bodies of different ſizes, which probably were its eggs.

There are in this infuſion ſeveral ſorts of eels, different amongſt themſelves, and different alſo from thoſe found in vinegar.

Fig. 298. repreſents one of them very thick with reſpect to its length, which was ſtored with a conſiderable number of exceeding ſmall fibres, and others alſo that ran ſpirally from near its head towards the tail.

At fig. 299. is exhibited another kind of eel-like animalcula of great vivacity.

Another of a larger ſize is alſo repreſented at fig. 300. that had been dead for ſome time, when by chance a little eel [e] was diſcovered fluttering very much to get out of the belly of its mother, but not being able to do it, at laſt died therein.

This obſervation is a ſufficient proof that the eggs of theſe eel-like animalcula are hatched in their mother's body.

Fig. 301. repreſents an animalcule, called a weaver's ſhuttle; it ſwims ſmoothly, having in the middle of its body ſeveral little corpuſcles reſembling eggs.

Fig. 302. is called the beak of an halbert, its head ends in a point; the other extremity of its body is like a drop, and upon the throat are ſeveral long hairs.

Fig. 303. is called a water-ſpider; it is of a ſpherical figure, with ſeveral brown parallel lines, between which are ſome ſpots browner than the reſt of their bodies.

Fig. 304. is called a drop, its body uniform and tranſparent, its neck long, but a little crooked.

Fig. 305. is called a ſlug, its head is round, tail ſharp, body large in proportion to its length, and becomes ſo ſhort in motion as to appear pretty regular.

Fig. 306. is called a water caterpillar, they are found of different ſorts, and in ſeveral infuſions of plants; it has been before obſerved, that the hairs, of which we have elſewhere ſpoke, are planted on the two lips of this caterpillar, which ſeem to turn at certain times like the rowel of a ſpur.

Fig. 307. is called the great aquatic ſpider, its figure ſomewhat ovaliſh, mouth a little ſunk, which appears ſometimes to reach to the middle of its body, its lips are adorned with hairs in motion, which ſeem to have a communication with a little part that probably may be the heart, and lungs ſurrounding it; its hinder part is alſo furniſhed with hairs that form a kind of tail; a little above the anus is a brown ſpot, ſuppoſed to be the excrement; the reſt of their body is generally ſtored with little regular corpuſcles.

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[e] Joblott's Obſ. p. 76.

This ſort of animalcule is alſo found in infuſions of wheaten ſtraw, in that of barley mixt with ſome of the ears; in Turkey corn, Indian cane, in the wood and bark of acaias, or in that of whole pepper, &c. All theſe different ſorts of water-ſpiders, have hairs round their body, inclining a little from their head towards their tail, and may be ſeen with a lens of one twelfth part of an inch focus.

Fig. 308. is called great mouth, becauſe its mouth takes up about half the length of its body; its upper lip is much longer than the lower, and are each adorned with little hairs; its inſide is filled with darkiſh ſpots, and hinder part terminated with a ſingular tail.

Fig. 309, A B C, is named a funnel, and is here repreſented under three different forms, in the middle one the mouth is open and round, the inſide of its lips are adorned with little hairs, which have a quick motion; the inſide of its body ſtrewed with many little irregular ſpots, and its long tail generally drags after it little pieces of ſkin faſten'd to its extremity. The ſecond is ſeen at A with its mouth ſhut; and the third at C, whoſe body is rounder, and its tail at certain times twiſted in the form of a cork-ſcrew.

Fig. 310. hath a head like clover graſs, and a forked tail; its mouth very ſmall and round.

Fig. 311. is called a ſock, the inſide of its body is adorned with ſeveral tranſparent ſpots, which appear like eggs.

At the time this infuſion was intended to be thrown away, it was thought proper to put a drop of it upon the object-carrying glaſs, and to examine it by the microſcope, whereupon one of the moſt particular of all the foregoing animalcula was found therein. It is a kind of water caterpillar, and ſo ſcarce, that no more than ſeven or eight could be found in many trials during three days. Fig. 312. ſhews three repreſentations of one of them; in that exhibited by A B, its body is ſeen to be compoſed of ſeveral ringlets, that enter one into the other, as the animalcule contracts itſelf; it puſhes out of its mouth a ſnout compoſed of ſeveral pieces ſheathed in each other, which are ſhewn at A C and D. The extremity of this ſnout appears to be perforated in ſome poſitions as at D; it is ſometimes ſplit in two parts, at other times into three, as at A, where they form two or three little protuberances. At L L are ſeen two lips furniſhed with moveable hairs. In other poſitions not one hair can be ſeen. While theſe things were obſerving, a kind of horn F, was ſuddenly protruded from its breaſt: its whole length appear'd to be compoſed of ſeveral furbelows of unequal thickneſſes, which go one into another like the drawers of a pocket teleſcope: at its tail are two very ſharp points as at B E, and in ſome particular poſitions it appears in three parts as at I.

Infuſion of the bark of a young oak.

ABOUT the twenty-fifth of December ſeveral little pieces of the bark taken from off a branch of young oaks were put into cold water, and in two hours after ſome of thoſe animalcules called ſilver bag pipes were ſeen therein; and on the fifteenth of January, in a very ſmall drop, was ſeen ſeveral new ones. Some of them Mr. Joblott called caterpillars, others ſtockings, ſtirrup-ſtockings, &c.

Thoſe repreſented at fig. 313. are called golden caterpillars, being of an amber-colour; the longitudinal fibres are ſeen from one end of its body to the other, between which are little irregular globules.

Fig. 314. is called a ſtirrup-ſtocking; at C is a great opening which changes its ſhape every moment, and appeared to be its mouth; the lips were ſometimes ſo extended as to ſerve it for a rudder to ſteer its courſe; its body was beſet with extremely ſmall hairs.

That repreſented at fig. 315. is in the form of a fiſhing-net.

Fig. 316. is another, of which the part G H reſembles an ill-ſhaped leg; the middle of its body appeared to be tied with an inviſible ligature.

Fig. 317. is called a club, its mouth intirely cloſe, and body ſhaped like one; ſeveral little globules were ſeen within-ſide, ſuppoſed to be eggs.

Laſtly, at fig. 318. is one of another kind of the bottle ſort, which ſwam amongſt the preceeding ones; and alſo a great number of other ſorts, which do not merit a deſcription. The cold weather increaſed ſo faſt, that in fifteen days time all the animalcules in this infuſion were deſtroyed.

Of ſome other larger aquatic animals.

THE waters every where are ſtocked with life, which makes the ſubject endleſs for the employment of the microſcope; ſeas, rivers, ponds, ditches, and almoſt every puddle, can preſent us with living wonders; but as theſe examinations have been very little attended to even by thoſe who are ſupplied with microſcopes, I hope theſe directions and the variable microſcope, will be a means to whet the inclinations of the induſtrious enquirer, the difficulties in the uſe of the common inſtruments being here removed.

Mr. Leeuwenhoek found ſome ſurpriſing animalcules, adhering to the lens paluſtris [f], or duck-weed, which he examined in a glaſs tube filled with water; one ſort of theſe were ſhaped like bells, with long tails, whereby they faſtened themſelves to the roots of theſe weeds. H M, fig. 319. repreſents a ſmall part of the root, as it appear'd in the microſcope, ſuppoſed to be almoſt withered and over-grown, with a great many long particles which are ſeen between K and L. The animalcula repreſenting little bells, [g] are ſeen at I S T.

On ſeveral of theſe roots were obſerved one, and ſometimes two ſheaths or caſes of various ſizes faſtened thereto by the ſmall end: the largeſt is exhibited at R X Y, out of which ſheath appeared a little animal, whoſe fore part was roundiſh as at X Y Z, from whence proceeded two little wheels that had a ſwift gyration always one and the ſame way, and were thickly ſet with teeth or notches as at P Q R S. When they have for ſome time exerted their circular motion, they draw the wheels into their bodies, and their bodies wholly into their ſheath, and ſoon after thruſt themſelves out again and renew the aforeſaid motion. Mr. Leeuwenhoek obſerved the caſe of one of theſe animalcules to be compoſed of round bubbles, [h] as is repreſented at N, O, T. When this animalcule had thruſt that part of its body from O to P, out

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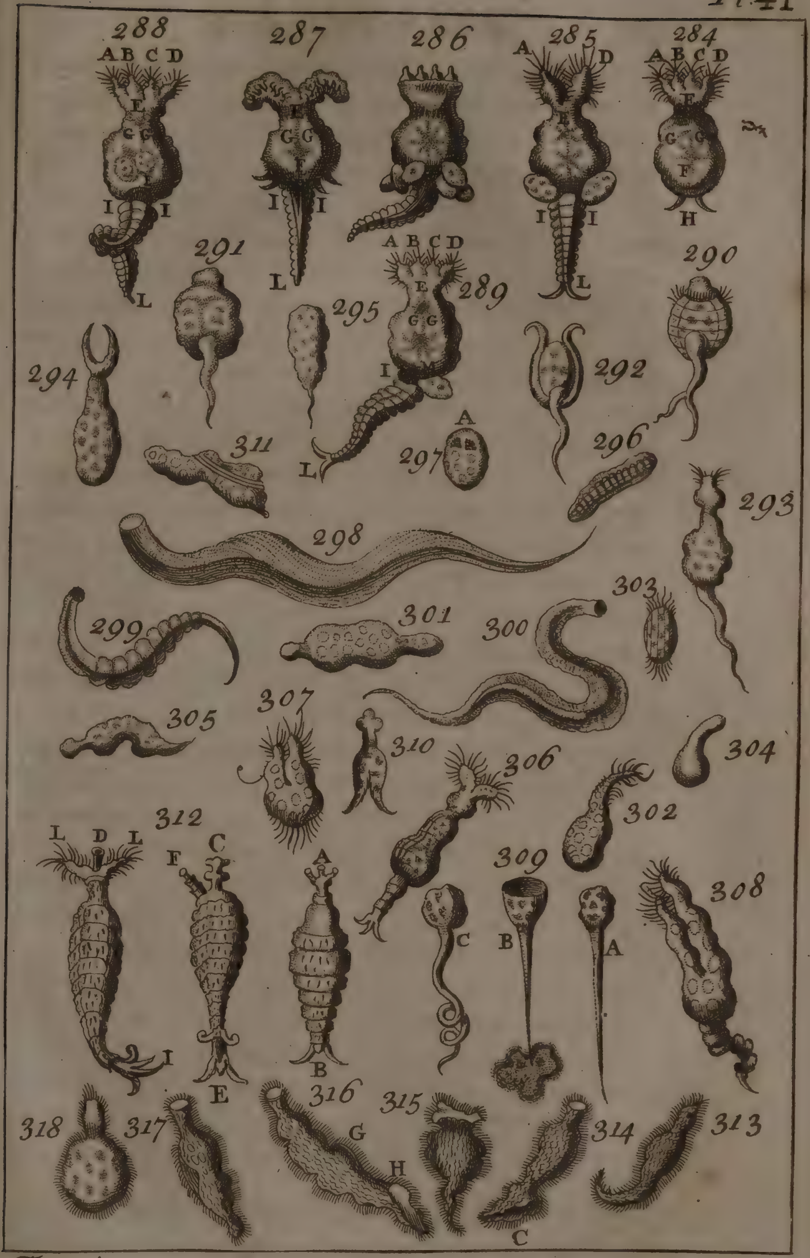
[f] Phil. Tranſ. No. 283, 295, 337. [g] Ibid. No. 283.
[h] Ibid. No. 295.

Pl. 41



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out of its ſheath N O, it extruded at the ſame time that ſurpriſing wheel-work (which before was taken for two diſtinct little wheels, and was here plainly ſeen to be but one and the ſame circumvolution) that conſiſted of four round parts P Q R S, three of which were to be ſeen, the fourth being almoſt hid; its motion was from P to Q, according to the order of the letters. Fig. 320. repreſents the wheel-work by itſelf, and larger than it appeared to the ſight.

Mr. Leeuwenhoek found ſeveral kinds of theſe wheel-work animalcula in the ſlimy matter which is to be found in leaden pipes, or [i] gutters; when the water dries away they contract themſelves into an oval figure, and a reddiſh colour, and become fixed in the dry dirt, which grows as hard as clay; but if to this dirt you put water, in about half an hour's time they open, and by degrees extend their bodies and ſwim about; and this they did after ſome of this gutter-dirt had been kept dry for twenty-one months together: whence he concludes, that the pores of their ſkin are ſo perfectly cloſed as to prevent all perſpiration, by which means they are preſerved till rain falls, when they open their bodies, ſwim about, and take in nouriſhment.

Fig. 321. and 322. repreſents two of them in different poſitions, and fig. 323. ſhews how they appear when dry and contracted.

Several ſpecies both of cruſtaceous and teſtaceous animalcules are to be found in the waters of ditches; two of the former ſort are repreſented in fig. 324. 325. in the poſture they ſwim with their backs next the eye; their legs are ſomething like thoſe of ſhrimps or lobſters, but of a ſtructure much more curious; they are leſs than a very ſmall flea, are all breeders [k], and carry their ſpawn in

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[i] Leeuwenhoek's Arc. Nat. Tom. ii. Epiſt. 149.

[k] Phil. Tranſ. No. 288.

in two bags, which hang from their ſides, or under their tail, as in fig. 325. Theſe bags are ſometimes ſeen broke, and the ſpawn ſcattered about the water. There is a third ſort amongſt theſe as beautiful as the foregoing, but not near ſo large; its ſhape nearly reſembles a ſhrimp, and carries its ſpawn as the ſhrimp does. Theſe three kinds of animalcula have but one eye, and that placed in the middle of their forehead; they are often to be found ſo tranſparent, that the motion of their bowels is very plainly diſcovered by the microſcope, together with a regular pulſation in a little part, which we may ſuppoſe the heart.

In the ſummer-time it is common for the water in ditches to appear ſometimes of a greeniſh, and ſometimes of a browniſh colour, which upon examination by the microſcope is found to conſiſt in infinite numbers of animalcula, blended together on the ſurface of it, and giving it ſuch an appearance; their ſhape is oval, but the middle either green or red, ſeems to be compoſed of globules, reſembling the roes or ſpawn of fiſhes.

Of the freſh water polipe, with arms in form of horns; of their motion and ſtructure.

THE nature of this inſect is both extraordinary, and contrary to the general received opinions of animal life, and requires the moſt convincing proofs to perſuade many people into a belief thereof. In order therefore to clear up this peculiar affair, I ſhall lay before the reader the following obſervations, which were made by Mr. Trembly, and alſo aſſure him, that I have repeated the major part of his experiments on this animal with the ſame ſucceſs.

And firſt theſe animals were not hitherto entirely unknown, for Mr. Leeuwenhoek gives a deſcription of a ſurprizing ſort of minute animal, in the Philoſophical Tranſactions, number 283. It is repreſented at fig. 328. as it appear'd faſtened to a root of duck-weed, whilſt in the water, and about three times bigger than it appeared to the naked eye; this was a large one of the ſort, and had eight horns: at C is ſhewn a very ſmall animalcule coming out of the other's body, ſuppoſed at firſt to be faſtened thereto by ſome accident; but on a cloſer examination, was found to be a young one in the birth, although it had at firſt but four ſmall horns; after ſixteen hours its horns and body was grown much larger, and in four hours more was quite excluded its mother's body; againſt this on the other ſide appeared a little round knob, which gradually increaſed in bigneſs, and in a few hours was pointed as at D, fig. 328. About fourteen hours after it was grown much larger, and had two horns; three hours after it alſo fell off from its mother and ſhifted for itſelf.

An Engliſh gentleman [1] diſcovered one of them in ſome clear water taken out of a ditch; but with the utmoſt attention he could find no more therein. It appeared the firſt day as at fig. 326. but varied every moment, and the knob at a, looked like the gut cenum; two or three days after he obſerved ſome white fibres at the extremity of the knob; on the fourth it was extended at full length, and appeared as fig. 327. which then convinced him this excreſcence was really an animalcule of the ſame ſpecies, having ſix horns; next day he found it ſeparated from its mother; it is ſeen in its contracted ſtate as delineated by this gentleman at fig. 329. and 330.

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[1] Phil. Tranſ. No. 288.

There is a near agreement between the obſervations of theſe two gentlemen, both of them having diſcovered the moſt remarkable property of the polypes, that is to ſay, their natural manner of multiplying. They have alſo given us their exterior figure, and ſome of their motions; but their more ſurpriſing properties, were reſerved for the diſcovery of the inquiſitive and happy genius of Mr. Trembley. It was alſo known to ſeveral other gentlemen before him, but none of them diſcovered this remarkable re-production, which is found in the different parts of a polype after they are ſeparated, each diſtinct piece becoming as perfect an animal as that of which it was only a part.

Mr. Trembley having taken notice of ſome plants, which he had taken out of a ditch, and put into a large glaſs full of water, and employing himſelf in conſidering the inſects therein contained, he caſt his eye upon a polype, which was fixed to the ſtalk of an aquatic plant, and is repreſented at fig. 331.

Their bodies a b are very ſmall, and from one of their extremities at a, proceed ſeveral horns, a, c, which ſerve them for feet and arms, and are much ſmaller than their bodies. I call the extremity a, anterior, becauſe it is the polype's head; and the oppoſite extremity b, poſterior.

The firſt ſort of polypes Mr. Trembley found, were of a fine green colour, and in the poſture of thoſe repreſented by fig. 331. The firſt motion he obſerved in them was that of their arms, which they extend and contract, bend and wind divers ways; they alſo contract their bodies upon the leaſt touch, ſo ſhort that they appear only like a grain of matter. They conſtantly turn themſelves towards the light; for if that part of the glaſs in which they are, be frequently turned from the light, they will be found the next day to have removed themſelves to the light ſide of the glaſs, the dark ſide being quite depopulated.

For Mr. Trembley incloſed a great glaſs well ſtored with green polypes, in a paſte-board box, which had a hole cut on one ſide in the form of a chevron, that exactly anſwered to the middle of the glaſs in which the polypes were: when this hole was turned to the light, it always happened, that the polypes aſſembled themſelves together at that ſide of the glaſs, and alſo in the form of the chevron; although the glaſs was turned ſeveral times in this box, yet at the end of a few days the polypes were always found ranged as before. To vary this experiment, he turned the chevron upſide-down, and notwithſtanding this, the polypes always aſſembled themſelves together, and in the form of the chevron, whether right or inverted.

The twenty-fifth of November 1740, Mr. Trembley cut a polype tranſverſly (for the firſt time) but the head part a little ſhorter than the tail part, and put the two parts into a flat glaſs, in which the height of the water did not exceed a quarter of an inch, by which means they might be eaſily obſerved with a pretty deep magnifying glaſs.

In that inſtant the polype was cut, both parts contracted, and ſunk to the bottom of the glaſs, like two little grains of green matter. Some few hours after both the parts ſtretched themſelves out, and were eaſily to be diſtinguiſhed from each other, the anterior end of the firſt being furniſhed with horns, whereas the other had none at all.

The firſt part moved its arms, and the next day he ſaw it change its place in the glaſs, and both were obſerved to extend and contract themſelves for ſeveral days.

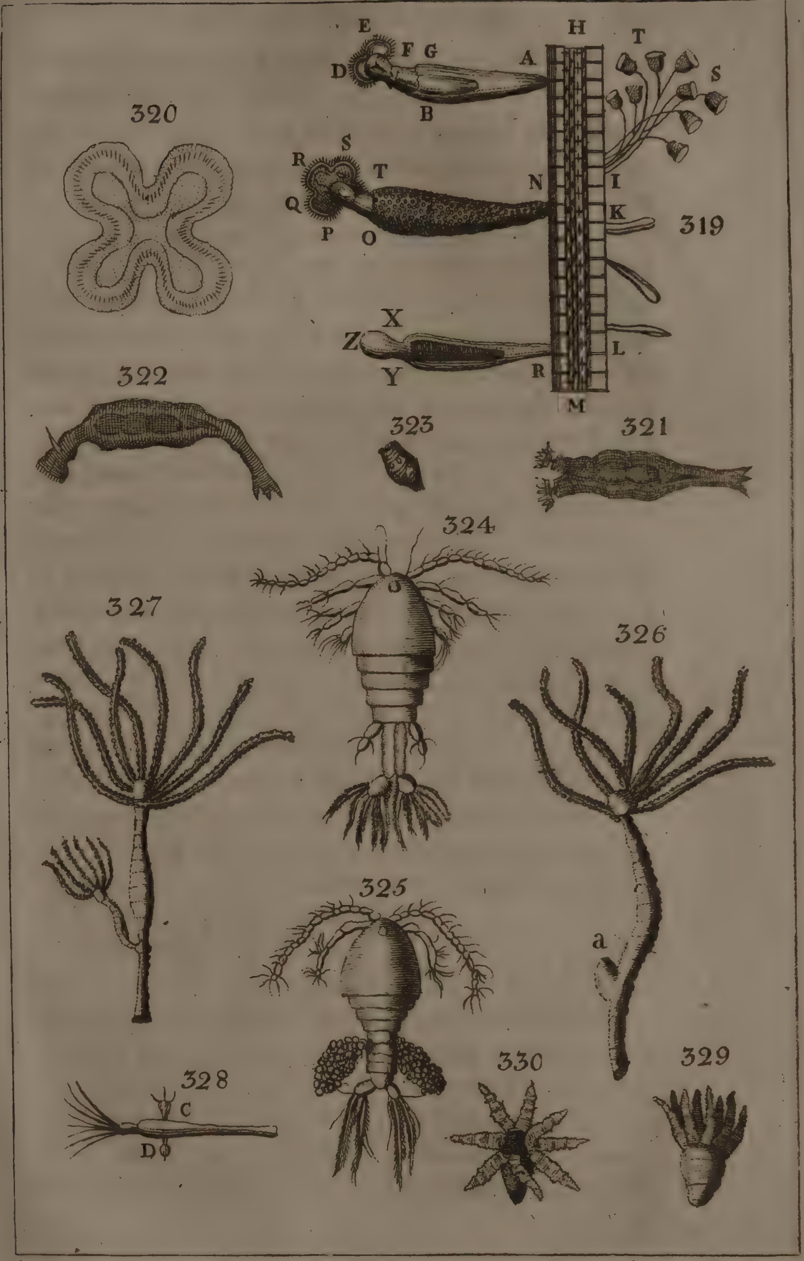
He only looked upon the motion of theſe two parts, as ſigns of the weak remains of life, eſpecially with reſpect to the hinder part, and therefore obſerved it only to know how long it would remain alive, not in the leaſt hoping to be the ſpectator of this ſo marvellous a reproduction.

But obſerving the cut pieces on the ninth day with a magnifying glaſs, perceived three little points coming out from the edges of the anterior end of the ſecond part, which had neither head nor arms. The next day he was convinced they were arms, and the day following two new arms came out, and ſome days after three more; this ſecond part had then eight, which in a little time was as long as thoſe of the firſt part, ſo that now there was no difference between the ſecond part, and a polype that had never been cut. They both appeared ſenſible, being each of them compleat polypes, and performing all the known functions of ſtretching themſelves out, contracting and walking.

After this he diſcovered one in a great glaſs he had by him, which was well ſtored with green polypes, from which young ones began to ſhoot.

In the month of April he found a new ſort of polypes, repreſented at fig. 332. and ſoon after ſaw them eat and ſwallow down worms longer than themſelves, and to digeſt them and be nouriſhed therewith: therefore this is a certain proof of their being animals.

They are to be found indifferently upon all ſorts of aquatic plants, and other bodies that are in the water (upon which they fix themſelves by the tail) at the bottom of ditches, and are ſuſpended upon the ſurface of the water, upon branches of trees, boards, rotten leaves, bits of ſtraw, ſtones, and many of them Mr. Trembley hath



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hath found on the bodies of divers animals, as on the ſhells of ſnails, &c.

The beſt way to find them, is to take up the different bodies and put them in glaſſes full of water, and if there are any polypes, they will ſoon be perceived adhering to thoſe bodies and moving their arms.

Mr. Trembley hath alſo taken the trouble of going often to the ſides of the ditch in which he found them, at a time when the ſun ſhone upon the bottom of the water, and choſe thoſe places where the water was clear, and that had an eaſy declivity, and ſays, he hath diſtinctly ſeen them at the bottom of the water, on all the bodies that were therein, and on its ſuperficies; by which means he acquired thoſe ideas concerning them, he could never have attained to without this precaution.

The moſt common poſture they are generally found in, whether in their ordinary places of abode, or in glaſſes, is repreſented by the figures 331. and 332. The poſterior end b, of the polype a b, is fixed againſt a plant e f, fig. 331. or againſt a ſtraw g h, fig. 332. the body a b, and arms a c, being extended in the water.

The general figure of the polype's body in this attitude is not perfectly the ſame; in the three kinds of polypes here deſcribed, the body of the green ones, fig. 331. diminiſh from their anterior to their poſterior end, the diminution being almoſt inſenſible.

That ſort repreſented fig. 332. are the ſame; but thoſe of the third ſort, fig. 333. differ from the two preceding ones in this reſpect, that their body does not diminiſh inſenſibly, but from the anterior extremity a, to the part d, and ſometimes even to two thirds of the length of their body; as at d, fig. 334. becoming from this point much finer, and do not diminiſh from thence to the poſterior end. They wave their arms in all directions, as at a, i, k, fig. 331. at a and e, fig. 332. and at a, fig. 333. and 334. The number of their horns in theſe three ſorts of polypes, is generally at leaſt ſix, and at moſt twelve or thirteen, yet nevertheleſs there are ſome few of the ſecond ſort which have eighteen arms. They can contract their bodies till they are not above the tenth of an inch or thereabouts in length: for example, that repreſented at fig. 333. could contract itſelf ſo as to become like thoſe two repreſentations fig. 335. They can alſo ſtop at any degree either of extenſion or contraction, from the greateſt to the leaſt.

The green ones are generally about half an inch in length when ſtretched out. Thoſe of the ſecond and third ſort are moſt commonly between three quarters of an inch and an inch; but ſome may be found of both ſorts, whoſe bodies are an inch and half long.

They grow ſmaller as they extend, and increaſe in bulk as they contract themſelves. The figures 331. 332. and 333. repreſent the general and natural ſize of theſe three ſorts of polypes; and at fig. 362. is an exact repreſentation of one, as it appears in the microſcope.

You may oblige them to contract more or leſs, in proportion as they are touched, or as the water in which they are, is agitated more or leſs. Every polype, when taken out of the water, contracts itſelf in ſuch ſort, as to appear like a mere lump of jelly on the body it is faſtened to, as at fig. 336. which figure is ſo different from what it bears when ſtretched out, that it can ſcarce be known at firſt ſight, but when the eye is once accuſtomed to it, they are eaſily diſtinguiſhed from all other bodies that are out of the water.

Heat and cold hath the ſame effects on the polypes, as it hath upon all other land and water inſects. Heat animates, and cold benumbs, or makes them faint and languid; yet nevertheleſs it requires a conſiderable degree of cold, to reduce them to a motionleſs ſtate, and that muſt be very near to that of freezing, at which time they are more or leſs contracted, and ſo remain; but as ſoon as the water in which they are, acquires ſome degree of warmth, they ſtretch themſelves out, and move proportionably to the heat thereof. It is not neceſſary that this degree of heat be very conſiderable, but is ſufficient for them, if the water be of a temperate heat, which is exactly ſhewn by the fifty-ſecond degree on Farenheidt's thermometer [m].

The arms of the green polypes ſeldom exceed the length of their bodies, as at fig. 331. An inch is commonly the length of the arms of the ſecond ſort, as at fig. 332. though ſome are longer. The arms of the third ſort are generally about eight inches, fig. 333. for which reaſon Mr. Trembley calls them long armed polypes.

The polype can extend and contract its arms, without extending or contracting its body; and its body, without any alteration in the arms; it can alſo extend and contract all or ſome of its arms, independant of the others.

Its body and arms are alſo capable of bending in all poſſible directions, ſome of which are repreſented by fig. 337. in which attitude they are ſometimes found; the body and arms can alſo twiſt themſelves, as at fig. 338. and 334. It is likewiſe remarkable, that the arms of the ſecond and third ſorts of polypes, generally bend at ſome diſtance from their joining to the body.

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[m] Farenheidt's Thermometers, as well as thoſe of Sir Iſaac Newton, Mr. Reaumeur, D'Liſle, and others may be had at my ſhop, made after the beſt manner, and graduated from actual experiments; at Tycho Brahe's head, No. 60. in Fleet-ſtreet, London.

The third ſort, for the moſt part, let their arms hang down, making different turns and returns, as at fig. 333. and ſometimes they direct ſome of them towards the top of the water.

Their progreſſive motion is performed by means of that faculty they have of ſtretching out, contracting, and turning themſelves every way. For let the polype a b, fig. 349. be fixed by its poſterior end b, having its body a b, and arms extended in the water, in order to advance, it draws itſelf together, by bending its body on whatever it moves; and then fixing its anterior end a upon this body, ſometimes the anterior end only, at other times ſome of its arms, and at others the arms and anterior end a, as at fig. 350. When the anterior end is well fixed, it looſens the poſterior end b, and draws it to the anterior a, faſtening the end b, as at fig. 351. after which it again looſens its anterior end a, and ſtretches it out, as at fig. 352. Thus much for a general deſcription of the common ſteps a polype makes in moving from place to place.

They walk very ſlow, and often ſtop in the middle of a ſtep, diſpoſing of, and winding their body and arms every way; as at fig. 338.

Sometimes they make an extraordinary ſtep, as follows, let the polype a b, fig. 353. be fixed by its poſterior end b, and its body and arms extended in the water. Firſt it bends its anterior end a, towards the body upon which it moves, and fixes it at a, fig. 354. after which it looſens its poſterior end b, and raiſes it up perpendicularly, as at fig. 355, then bending its body to the other ſide, fixes the poſterior end b, as at fig. 356. and looſening the anterior end a, raiſes it up again, as at fig. 357.

The third kind of ſtep the polype makes, is in the following manner; let the polype a b, fig. 358. be fixed by its

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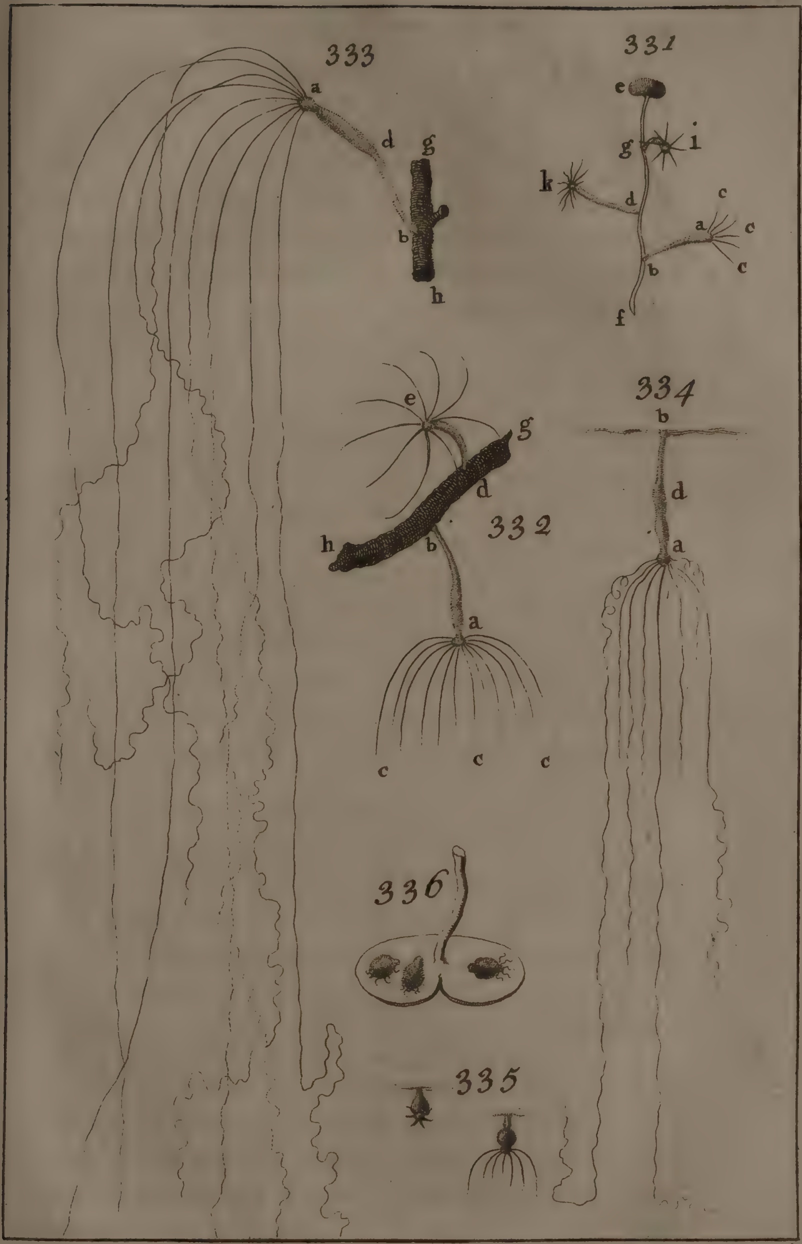

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its poſterior end b againſt the ſide of a glaſs; its body, and moſt of its arms being ſtretched out forwards, and one of its arms a c, fixed againſt the glaſs at c: when the polype is in this attitude, it looſens its poſterior end b, and contracting its body, draws it up a little nearer to the point c, and fixes it againſt the glaſs at d, after which it repeats the ſame and fixes its poſterior end at e, and ſo on. All that is here ſaid of the polypes progreſſive motion equally reſpects the three ſorts.

They deſcend to the bottom of the water, and come up either by the ſides, or upon aquatic plants, and often hang down from the ſurface thereof, by their poſterior end, as at b, fig. 334. and are often ſeen to ſuſpend themſelves by one arm only, as at c, fig. 339. They walk as well upon the ſuperficies of the water, as upon thoſe bodies juſt mentioned; and perform the ſame motions in a glaſs, as they do in greater waters: They paſs over plants or other bodies; they go up the ſides of glaſs, even to the ſurface of the water, and paſs either under or over it, and ſometimes reſt themſelves there; then they march to the oppoſite ſide of the glaſs, and ſo deſcend to the bottom.

If you examine the extremity of a polype's tail, while it is ſuſpended, as at b, fig. 334. (from the ſurface of the water) with a magnifying glaſs, it will be found a little out of the water, ſomewhat concave and dry, as at b and c, fig. 359. and to prove that this circumſtance is abſolutely neceſſary to ſupport them on the ſuperficies of the water, only wet the dry end with a drop of water, and the polype will immediately fall to the bottom.

When a polype deſigns to paſs from the ſides of a glaſs, to the ſuperficies of the water, it need only put that part out of the water by which it would be ſupported, and give it time to dry, which is what it always does, and what may eaſily be obſerved. If, for example, a polype is fixed againſt the ſides of a glaſs, near the ſuperficies of the water, (on which it intends to go) as at e f, fig. 359, in order to convey itſelf thither, it raiſes up its anterior end, and puts it out of the water, there letting it dry, then looſening its poſterior end f, from the glaſs, draws it up, and puts it above the water, where it alſo becomes dry in an inſtant, and capable to ſupport the polype, upon which it draws its anterior end under water, and remains ſuſpended from its ſurface, as at c and b, often extending its body and arms.

It has been often found neceſſary, in the courſe of theſe experiments, to ſuſpend a polype from the ſurface of the water, becauſe they are not always to be found ſuſpended there of themſelves. To effect which, take in one hand an hair-pencil, and in the other a pointed quill, or a tooth-pick; with the pencil looſen the polype from the glaſs, and gradually raiſe it near the top of the water, in ſuch a manner, that the anterior end of the polype be next the point of the pencil; then lift it out of the water, and keep it ſo for a moment, nay a minute if you will, after which thruſt the point of the pencil, together with the anterior end of the polype, by little and little under the water, until no more than about half the tenth of an inch of the polype's tail remains above its ſurface; at this inſtant, with the pointed quill, remove that part of the polype from the pencil, which is already in the water, and at the ſame time blowing againſt the polype, its tail will be alſo looſened, and remain out of the water.

A polype, that is already ſuſpended, may be removed from a glaſs of dirty water, to a clean one with freſh water, by endeavouring to place the pencil parallel to the polype, and in this poſition to advance it gradually till it touches him, he will then apply himſelf againſt the pencil, and on being drawn out of the water, its tail, which was dry before, will remain ſo; and it may be immediately put into the clean water, by obſerving the foregoing directions.

Polypes commonly fix their tail to ſtones, or aquatic plants, &c. ſo faſt as to prevent their being drove away by the ſtream, and are ſometimes fixed not only by their tails, but by two or three of their arms alſo, which they direct different ways; and being thus fixed cannot be toſſed about by the motion of the water.

Two long armed polypes ſuſpended from the ſurface of the water in a glaſs, are repreſented exactly in the poſition they were found, at a, b, and c, d, fig. 359. One of them d c, had two of its arms d, i, and d, k, fixed againſt the bottom of the glaſs, but on oppoſite ſides thereof, at i and k. The other a b had alſo one arm a g, fixed againſt the bottom of the glaſs, at g, and its other arm a h, fixed againſt the ſide at h; they held themſelves ſo faſt in this poſition, that the glaſs was forcibly ſhaken before they quitted their hold.

The polype's mouth is ſituated at the anterior end of its body, in the middle between the ſhooting forth of the arms. It is very often ſtretched out, at which time it repreſents a little conical nipple, as at a, fig. 333. and fig. 343. The cone it forms appears ſometimes truncated, as at a, fig. 362. At other times no nipple can be diſcovered, the interval between the arms being cloſed, as at a, fig. 338. and 344. in other circumſtances it is hollow, being open, and a little widened, as at i, fig. 331. or at e, fig. 332. and a, fig. 362. it is not only open in this circumſtance, for if it is obſerved with a magnifying glaſs, when flat, or when it forms a truncated cone, a little hole is generally ſeen at the end thereof, which is repreſented as it appears when magnified at a, fig. 362.

The different opening of the mouth and lips, are ſeen fig. 343. 344. and 345.

The polype's mouth opens into its ſtomach, forming a kind of bag or gut, from head to tail. The naked eye may be convinced of this, but much better if it be armed with a microſcope. It is exactly repreſented as it appears through the microſcope at a b, fig. 262.

Mr. Trembley not being ſatisfied that the polype was perforated from end to end, by only obſerving it from without, cut one tranſverſly into three parts, each piece immediately contracted itſelf, and remained very ſhort, and being all three placed on the flat bottom of a ſhallow glaſs full of water, and viewed through a microſcope, from the upper end, the bottom of the glaſs was ſeen through the lower, ſo that all the three were viſibly perforated; they are repreſented as they appeared in the microſcope, by the figures 340. 341. and 342. Its mouth was at the anterior end of one of theſe parts a, fig. 340. and was then wide open. The poſterior extremity was at the end b of the third part, fig. 342. as this piece was perforated through, it plainly appears, that the tails of the polypes are alſo open.

This perforation which is continued from one end to the other of the polype, is called the ſtomach, becauſe it contains and digeſts the aliments, and the ſkin which incloſes the ſtomach, and forms this bag, is the very ſkin of the polype. Therefore the whole animal conſiſts but of one ſkin, diſpoſed in the form of a tube or gut, open at both ends.

If a polype be obſerved with the microſcope, its whole body appears like ſhagreen, or as if it were ſtrewed with little grains, as repreſented at fig. 362. both when contracted or extended, it is more or leſs varied according to theſe or other circumſtances.

If the lips of a polype be cut tranſverſly and placed upon the object-carrying glaſs, in ſuch a manner as that the cut part of the ſkin a, fig. 341. may lie directly before the microſcope, it will be found to conſiſt of an infinite number of thoſe little grains throughout the whole thickneſs of the ſkin: therefore, in order to know whether the inſide of the ſtomach had any of the like grains, Mr. Trembley opened ſeveral of them in the following manner; by putting a polype upon his hand, he made it, by touching, to contract as much as poſſible, and then he introduced a very fine point of a pair of ſciſſars into its mouth, and forcing it out at the tail, and immediately cloſed the ſciſſars, which cut one ſide of the polype's ſkin from the top to the bottom, and laying it open from one end to the other diſcovered the interior ſuperficies thereof, which is repreſented as it appeared in the microſcope at fig. 346. and this was alſo compoſed of as great a quantity of the ſame grains as the exterior ſuperficies and the edge a, of the cut piece of ſkin, fig. 346. To examine theſe particulars a little farther, a bit of the ſkin was laid upon a glaſs ſlider in a drop of water, and placed before the microſcope, a, fig. 347. and ſome of theſe grains ſeparated therefrom, as at b, c, d, by preſſing them with the point of a pin, ſtriking them againſt the glaſs, and endeavouring to tear them in pieces; the grains ſpread themſelves to all parts of the water, and at laſt remained in heaps as at e and f.

If a polype be carefully placed before the microſcope, ſo as not to wound him, you will ſeldom be diſappointed of ſeeing thoſe grains ſeparate from ſome part or other, and that in the moſt healthy polypes; but when they ſeparate in large quantities, it is a certain ſymptom of a dangerous illneſs. The ſurface of the polype from which they fall becomes irregular, and is no more terminated as before. The grains fall off from all ſides, it contracts itſelf, the body and arms ſwell and loſe their ſhining whiteneſs, and at laſt their form, as at a, fig. 348. and nothing is to be found in its place but an heap of grains as at b.

The ſtructure of the polype's arms bears a near reſemblance to that of its body; and when obſerved with the microſcope, we find their exterior ſurface to appear ſhagreened alſo, fig. 362. an arm much contracted appears extremely ſo, and even much more ſo than the polype's body.

If a ſuſpended arm that extends itſelf be obſerved, the grains may be ſeen a little aſunder, which when contracted almoſt touch, but ſo that intervals are left between them, as at fig. 363. When at a certain degree of extenſion, its ſurface ſeems only to be ſtrewed with pimples as at fig. 364. which continue ſtill to ſeparate, as the arms extend, and are at laſt placed upon a thread e e e, fig. 365. Theſe pimples are formed by the reunion of many grains, and at the firſt glance appear like a ſtring of beads, fig. 365.

The different ſtates of a polype's arm, may be obſerved at the ſame time, in the ſame arm, but at different places thereof, by caſting the eye, armed with a microſcope, from one end of the arm to the other, and eſpecially if the ſeveral portions thereof be carefully obſerved with a large magnifier, they will appear as at fig. 363. which repreſents that part of the arm ſtretched out, which is near the polype's head, the grains thereof being but little ſeparated, but are farther aſunder in fig. 364. which is about the middle of the arm; and fig. 365. ſhews the grains as if they were ſtrung upon a thread, as they are ſeen upon the extremity of a polype's arm.

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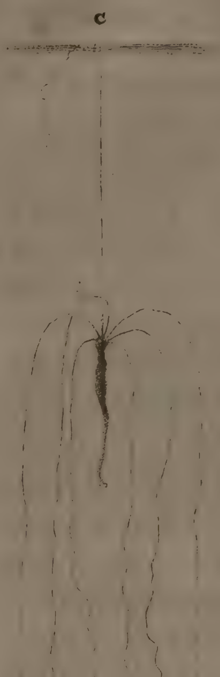

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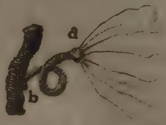

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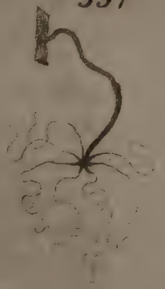

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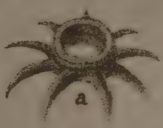

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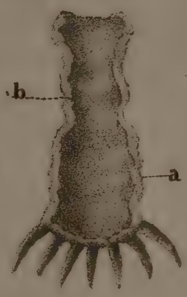

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This extremity is often terminated by a knob, and the hairs marked e, e, e, fig. 364. 365. are tranſparent, and may be ſeen with the firſt and ſecond magnifiers.

The beſt method to obſerve a polype's arm, is to chooſe one that is fixed to the ſide of a glaſs, and near the ſuperficies of the water: at which moment, any one of its arms being very well extended, take a pair of nippers in one hand, and a ſlip of glaſs, about two or three inches long, and half an inch broad, in the other, holding it at one end between the finger and thumb; then with the nippers, or a pointed quill, pull the end of the arm gently out of the water, and the reſt will follow. If it is not ſtretched enough, ſtretch it more, by drawing it out, the polype ſtill remaining fixed to the glaſs; put the arm upon the ſlip of glaſs, and turn it under till it meets itſelf again; then giving it a jirk, the arm will break off on both ſides the ſlip of glaſs, one part remaining with the polype, and the other in the forceps, and the middle part will ſtick upon the glaſs ſlip, in which manner it may be applied to the microſcope, and preſerved for ſeveral days, as well as when it is at firſt taken out of the water, for when once dry it does not change for a conſiderable time.

Of the polypes food, and manner of their ſeizing upon, and ſwallowing their prey.

IT was ſome time after the diſcovery of the ſecond ſort of polypes, before Mr. Trembley could find out a proper food to nouriſh them, but the water at that time happened to be plentifully ſtored with a ſort of millepedes, fig. 360. ſmall enough, and about three quarters of an inch in length. They are remarkable for a horn, or fleſhy dart, proceeding from the fore part of their head at d. Mr. Reaumeur had called them darted millepedes. They ſupport themſelves, and ſwim in the water by means of the ſeveral ſwift inflections they make with their bodies; they reſt themſelves, and creep upon all the bodies they meet with, and are often found in great numbers upon aquatic plants; thoſe upon which the firſt polypes of the ſecond ſort were found, were well ſtocked with theſe millepedes, and were taken out of the water together with them, and put into the ſame glaſs without any deſign.

A few days after the anterior end a, of a polype, fig. 366. was obſerved, with one of theſe millepedes partly within its mouth, and the other part yet without it at m, not knowing at firſt whether the polype was eating the millepedes, or whether the millepedes had introduced itſelf voluntarily into the polype's ſtomach, to be nouriſhed there, to lodge its eggs, or depoſite its young therein, but at laſt it was entirely entered into the polype's body.

The long armed polypes being the moſt remarkable in their feeding, &c. for that reaſon principally, Mr. Trembley thought proper to deſcribe theſe experiments, upon that ſort, from which one may eaſily judge the ſame of the other two ſorts.

To ſee theſe polypes ſeize their prey with their arms extended, they muſt be put into a glaſs, ſeven or eight inches deep, if the polypes are fixed to the top of the glaſs, their arms for the moſt part hang down towards the bottom. This is then the moſt convenient ſituation to give them food, and to obſerve how they manage it. To this end one might cauſe them to hang from the ſurface of the water, but this expedient is not always beſt.

The polypes we breed and feed, are commonly infeſted with little lice, it is therefore neceſſary to cleanſe them from theſe tormentors, by rubbing them with an hair pencil, and if the polypes ſuſpend themſelves from the ſurface of the water, it is ſcarce poſſible for them to be freed from theſe lice. In that caſe make the polypes fix themſelves to a packthread, or fix them to it, as at fig. 367. at the place b, letting the two ends h f, and k g hang down over the edges of the glaſs. One may then ſtroke them even ſomething rudely, backwards and forwards, with an hair pencil, without pulling them off, and in changing the water, only take hold of each end of the pack-thread, draw it gently out of the water, and put it immediately into another glaſs, prepared for its reception. If ſeveral of theſe pack-thread ſtrings are put into a glaſs well ſtored with polypes, there will be always ſome that will fix [n] themſelves thereto.

When the arms of the polype are well extended, put a millipedes, or any other worm into the glaſs, and with the point of a pencil, puſh it to one of the arms, which it no ſooner touches, but it is ſeized, and when the millipedes m, c, n, or worm, perceives itſelf taken, it endeavours by very quick and ſtrong efforts to diſengage itſelf, often ſwimming and dragging the arm a c, fig. 367. from one ſide of the glaſs to the other; this violent motion of the millipedes, obliges the polype to contract its arms, in the performance of which he often diſpoſes them in the form of a corkſcrew, o i, which alſo contributes to the ſhortening of it. The millipedes by its continual ſtruggles, entangles itſelf in the arm that holds it, m i n, and often meeting with other arms, they alſo aſſiſt, and with a ſudden pull, enable the polype to con-

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[n] Hiſt. de Polyp. p. 85.

tract himſelf, or to draw near his prey, and in an inſtant the entangled millipedes is conveyed to the mouth, againſt which it is held and ſubdued.

When a polype hath nothing to eat, its mouth is generally open, but that ſo ſmall that it cannot be ſeen without the aſſiſtance of a magnifying glaſs: whereas, as ſoon as the arms have conveyed a prey to the mouth, it opens itſelf more, and always in proportion to the ſize of the animal that is to be devoured; its lips gradually dilate, and preciſely adjuſt themſelves to the figure of their prey.

All the worms which are ſeized by the polypes, do not preſent themſelves in the ſame manner to their mouth; for if the worm preſents itſelf by one of its extremities, it is not requiſite the polype ſhould open its mouth conſiderably, neither does it open otherwiſe, but preciſely to give entrance to the worm, fig. 366.

If the worm is not too long for the ſtomach, it remains therein extended; but if longer, that end which firſt entered bends, and when it is entirely ſwallowed it may be ſeen folded within the polype, fig. 379.

When the middle or any other part of the worm is preſented to the polype's mouth, it ſeizes this part with its lips, extending them on both ſides, and applying them againſt the worm; at which time its mouth takes the form of a boat pointed at each end, fig. 368. after which the polype gradually cloſes the two points of its boat-like lips, which doubles the worm in that part, and ſo it is ſwallowed, fig. 369.

As ſoon as the ſtomach is filled, its capacity and the ſkin thereof is augmented, and the body becomes ſhort, fig. 372. its arms alſo are for the moſt part contracted. The polype hangs down without motion, and appears to be in a ſtate of numbneſs, and in ſhape very different

from

Pl. 45

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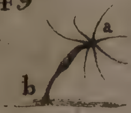

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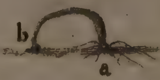

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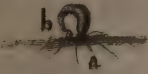

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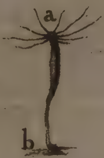

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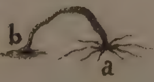

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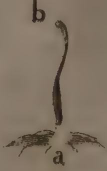

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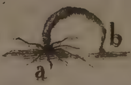

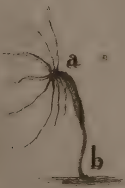

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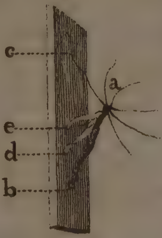

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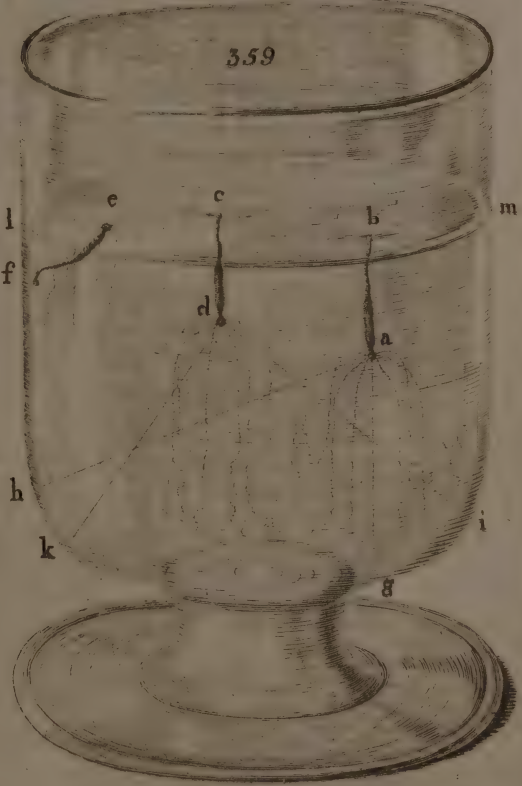

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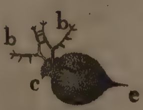

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from that of its extenſion, fig. 367. As the food digeſts, and it voids that which does not ſerve for nouriſhment, its body lengthens, and gradually recovers its natural form.

Mr. Trembley finding theſe millepedes a proper food for the polypes, he collected a great quantity of them, to feed thoſe he kept in glaſſes, and found them in ſwarms at the ſides of ditches, creeping on plants, and all other bodies that were in the water.

Alſo on obſerving how voraciouſly the polypes eat theſe millipedes, he imagined it was not the only agreeable food to them, and was therefore deſirous of finding out other animals to nouriſh them withal, beſides the trouble of getting a ſufficient quantity of millipedes from other places took up too much time; upon which he opened a polype that was taken out of the water, with its belly full of food; from whence came out little inſects, which he calls pucerons or fleas, and amongſt theſe another ſort that multiply extremely, and are often eaſily to be procured in great quantities; ſee the fig. marked p, at the end of one of the arms, fig. 367. which repreſents one of theſe fleas of its natural ſize, and as it appeared in the microſcope at fig. 361. They are exactly deſcribed by Swammerdam [o], and are remarkable for two branching arms, which proceed from their head, which ſerve them inſtead of fins. The arms inclined Swammerdam to call them by the name of puceron branchus; they are continually ſkipping about the water, and are generally ſomewhat reddiſh.

On putting ſome of theſe pucerons into a glaſs with polypes, they preſently ſeized on ſome of them, and began to extend their mouths, firſt in the form of a

concave,

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[o] Swammerdam's Hiſt. de Inſect. p. 86. Edit. de Leid. 1737.

concave, in which part of the flea is lodged, as at a, fig. 370. the lips continue to enlarge, till they included the puceron, and then entirely cloſe themſelves again.

The polypes are not content with two or three of theſe pucerons, but will continue to ſwallow them till the ſides of their ſtomach are ſo increaſed, as to contain two of theſe fleas in breadth one by the ſide of the other, as at fig. 371. which was abſolutely full from head to tail. If it be one of the third ſort, the narrow part of its body b d, fig. 372. generally remains empty, but ſometimes this alſo is forced to increaſe and receive ſome of thoſe fleas. When the polype hath ſwallowed no more of theſe fleas than can be contained within its ſtomach; its body, in that caſe, becomes very ſmall near the head, and forms in that place a kind of remarkable neck c, fig. 373.

If a number of theſe little fleas be haſtily thrown into a glaſs of hungry polypes, their arms are ſoon ſo loaded with them, that one can ſee nothing but a confuſed maſs of theſe pucerons gathered together, near the polype's mouth a, fig. 375. which they ſwallow one after another till they are entirely full.

So long as theſe pucerons could be procured, he fed his polypes with nothing elſe: his method of fiſhing them out of the water, was with a ſmall hoop, of about eight or ten inches diameter, made of braſs, or iron wire, to which was faſtened a pouch of linen cloth, and the whole tied to the end of a ſtick. This being put ſlopewiſe into the water, where there is a quantity of theſe animals, may be eaſily moved to and fro, any way you ſee occaſion, by which means the fleas will be gathered together into the hoop. You may then put them into a glaſs of water, which will ſwarm therewith from the beginning of June to the end of September; theſe were eaſily to be procured, but when they began to fail, he was at a loſs to find out other nouriſhment for his polypes.

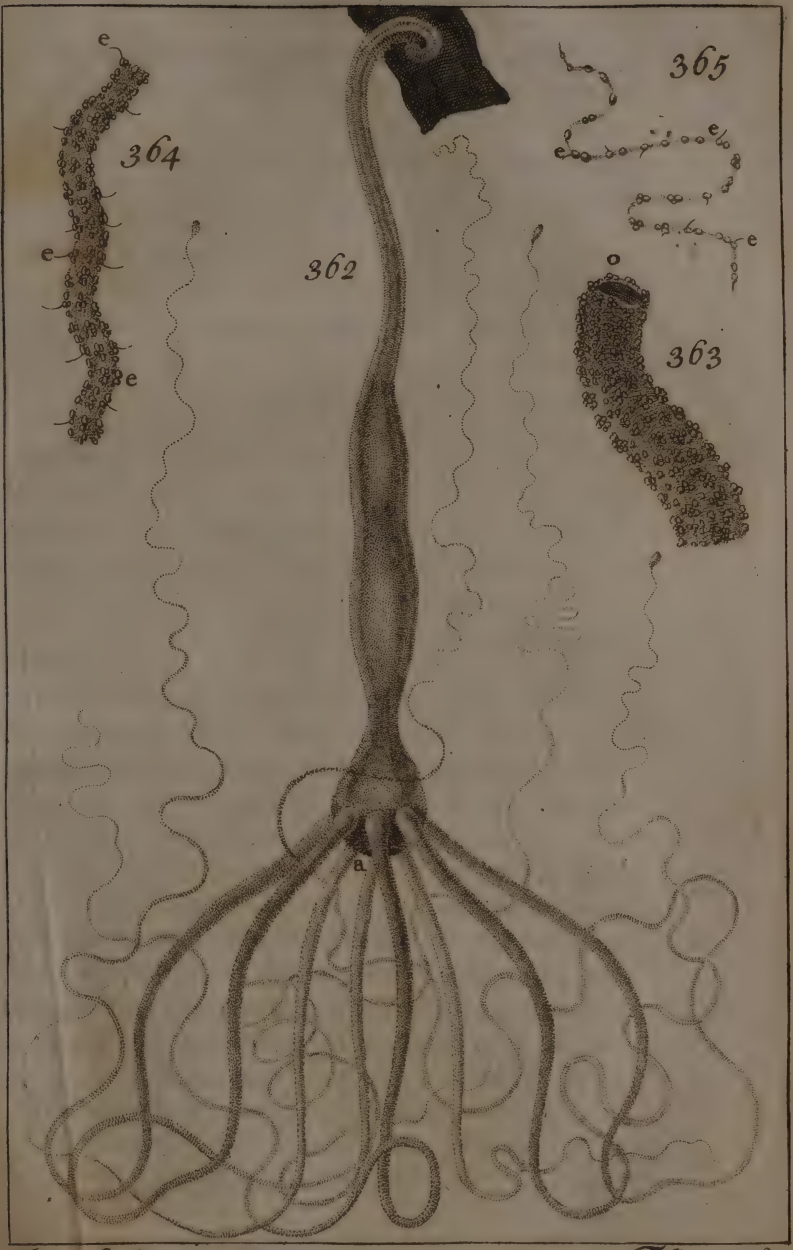
He went ſeveral times a day to the water-ſide, which had before a long time furniſhed him with fleas, and ſtooped down near the ſurface of the water, endeavouring to diſcover young ones, but all in vain; nevertheleſs in ſeeking theſe he ſaw ſeveral places at the bottom of the water, with worms all ſtanding an end, one end of which was in the earth, and the other end out of the earth in the water, making continual undulations, fig. 376. He thought, as ſoon at he ſaw theſe worms, they would ſerve to nouriſh the polypes, and to make up for the fleas he wanted, and the millepedes which could at that time be found only in ſmall quantities; it was with a great deal of trouble that he took up ſome of thoſe worms, which he gave to the polypes who eat them. Therefore, to procure as many of theſe worms as you may have occaſion for, you need only fix a circle of iron wire, two or three inches diameter, to the end of a ſtick, and putting this into the water, and about half of it under the earth, run it along a little way, always holding it in the ſame poſition, and that a little inclined; this will meet the worms, and drag them along with it, and bring up a large quantity thereof, which on ſhaking the wire circle in a glaſs of water, will all fall to the bottom. If the ditches where you fiſh for theſe worms ſhould be covered with leaves and herbs, it is neceſſary firſt to cleanſe them with a rake, before you put in the iron circle, otherwiſe you will get but few worms at a time. There are alſo other places ſo muddy, as to hinder the wire from holding the worms; in this caſe it is expedient, that you throw upon the mud ſome inches of ſand, for as the worms are obliged to keep part of their bodies above the ſuperficies of the earth, they quit the dirt, and paſs into the ſand, and remain near the ſuperficies thereof. They may be taken in very great quantities, after preparing the bottom of the water in this manner.

Theſe worms are found in great abundance in the mud of the river Thames; when the tide is out, they riſe in ſuch ſwarms on the ſurface thereof, that it appears of a red colour.

You may give to each polype a worm much longer, and alſo a little thicker than the polype is when extended; but then care muſt be taken to let the worm fall upon their arms, otherwiſe they will miſs of them, becauſe they fall directly to the bottom. Their ſenſe of feeling is ſo delicate, that if a worm touches even the utmoſt extremity of theſe very ſlender arms, they immediately by claſping them about it, invelope and fetter it in ſo many places, that it is ſoon rendered uncapable of ſtruggling to any purpoſe, it eaſily yields, and at laſt is ſwallowed into the polype's ſtomach, fig. 380. where it may be diſcerned through the polype's ſkin.

Theſe worms are the beſt nouriſhment for the polypes, eſpecially in the winter, therefore if you gather a ſufficient quantity of them in November, and put them into large glaſſes full of water, with three or four inches of earth at the bottom, you will have a ſupply for the polypes all the winter, and may fiſh them up out of theſe glaſſes, as out of the river.

Sometimes a pretty thick red worm, about half an inch long, is taken up with the reſt, and is repreſented at c d, fig. 382. It is the ſame as that deſcribed by Mr. Reaumer, in the firſt Memoir of the fifth volume of his Hiſtory of Inſects, page 29.



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Polypes may alſo be nouriſhed by theſe worms, but they are more difficult for them to digeſt, and not at all fit food for them in winter.

Mr. Trembley hath alſo ſeen them eat a worm, which he calls a tranſparent tipula, of which Mr. Reaumer ſpeaks in the fortieth page of the memoir juſt cited.

Having in the month of June taken a great quantity of little fiſh, about four tenths of an inch long, he gave ſome of them to the polypes, but the extreme vivacity of this fiſh, was almoſt too much for them to encounter with; however, all the polypes that ſeized them, did ſwallow them, and the tails of the long armed ſort were obliged to ſtretch open to receive the fiſh: one of the ſecond ſort is repreſented at fig. 377. which had ſwallowed one of theſe little fiſh; and as its ſkin a b, was ſo tranſparent, and flexible, it took the form thereof, and appear'd like a fiſh with long whiſkers.

The polypes eat the major part of thoſe little inſects that are found in freſh water; they are very well nouriſhed with worms, and the nymphs of gnats, and other flies; they will alſo eat larger animals if they are cut into little pieces, as ſnails, and other larger aquatic inſects, and earth worms, the entrails of freſh-water fiſh, and butcher's meat, as mutton, beef, and veal.

Mr. Trembley put into the bottom of a veſſel, ſome of the earth taken out of a ditch, imagining that a great number of little inſects might be lodged therein, or at leaſt the eggs of ſome; which experiment ſucceeded very well, for from the end of February 1742. it was ſtored with various ſorts of little animals; but particularly with one ſort, which is incloſed in a two-fold ſhell; when this ſhell was but a little opened, they put forth ſeveral minute feet or arms, that move exceeding quick, and by means of this motion they ſwim. Theſe animals place themſelves upon all bodies they meet with, and are about the bigneſs of a grain of ſand; ſome polypes being put into this veſſel, without taking any other care of them, were nouriſhed therein, and multiplied for eight months.

Whence it appears, that large glaſſes or pails, thus prepared with earth, (at the bottom of them) taken out of ditches in the ſummer-time, will be a convenient reſidence for the polypes; for beſides thoſe inſect eggs that are contain'd in this earth, may be very often ſeen (eſpecially if the water in the glaſs be expoſed to the air) the ſpawn and nymphs of gnats, and of tupula, or water-ſpiders, &c. Theſe veſſels may then be ſucceſsfully employed, and will ſave the trouble of feeding the polypes we intend to preſerve, and alſo of often changing the water. But when it is not changed and cleanſed for ſome time, it is generally filled with an herb, as fine as hairs, in which the polypes entangle themſelves, and by which we are hinder'd from looking within-ſide, if the veſſel be not made of glaſs; however this inconvenience is prevented by putting into each veſſel a few aquatic ſnails, more or leſs in proportion to its ſize; they will eat theſe plants as faſt as they grow, whereby the water, and the ſides of the veſſel, will always remain clean.

Sometimes two polypes ſeize the ſame worm, and each begins to ſwallow its own end of the worm, continuing to do ſo till their mouths meet, fig. 378. In this poſture they remain for ſome time, after which the worm breaks, and each polype hath its ſhare; but at other times the battle does not end there, for each of them continuing to diſpute the prey, one of the polypes opens its mouth advantageouſly, and attempts to ſwallow the other polype with its portion of the worm, which he effects in ſome degree, and ſometimes almoſt entirely as at fig. 380.

Nevertheleſs this combat ends more happily than we can at firſt believe, in behalf of the devoured polype; for the other gets the prey entirely out of its ſtomach, and the devour'd one comes forth again ſound and ſafe from the body of its enemy, after having been detain'd there above an hour.

Polypes can eat a great deal at a time, and they can faſt a great while; and they void their excrements at their mouth.

After a worm is ſwallowed, the tranſparency of the polype's ſkin will permit us to ſee it diſtinctly, as at fig. 379. the worm gradually loſes its form, and is at firſt macerated in the ſtomach of the polype, the juice nouriſhes, and being ſeparated, the remains thereof are thrown out at the mouth, as at fig. 381.

It is alſo obſervable, that their aliments are puſhed backwards and forwards, from one extremity of the ſtomach to the other, which contributes much to its digeſtion; which motion may be ſeen in the microſcope, if you chooſe a polype that is not too full. This kind of periſtaltic motion ſpreads the nouriſhing juice all over the ſtomach. But for an obſervation of this kind, it is beſt to feed the polypes with ſuch aliments as can beſtow a lively colour'd juice; for example, thoſe worms whoſe inteſtines are full of a red matter, for by this means we may ſee, that this alimental moiſture is conveyed not only to the extremity of the body, but alſo into its arms; whence it is plain, that a polype's arms are perforated, each of them forming a kind of gut, which communicates with that of the body.

This was confirmed by examining a polype, which had ſucked the red matter contained in the inteſtines of a flat worm, fig. 383. Its body is of a tranſparent white, and inteſtines extreamly viſible, and of a crimſon red;

care muſt be taken to chooſe thoſe which are of a proper ſize for the polypes to ſwallow; they come out of the polype's body without being macerated, the red matter which was in their inteſtines being only extracted from them.

But this experiment was yet better confirm'd on giving a polype ſome bits of the ſkin of a little black, flat ſnail, to be met with in great abundance in ditches. The matter of this ſkin was ſoon reduced in the polype's ſtomach to a kind of pap, principally compoſed of little black fragments, and on examining their motion attentively with the microſcope, were ſeen to be drove about in their ſtomach, and to paſs from head to tail, and into their arms, even to a thread; and afterwards were ſent back into the ſtomach, and chaſed from thence to the extremity of the tail, and were again repelled from thence towards its mouth, and into the arms, and ſo on continually.

Theſe experiments were ſeveral times repeated, and ſucceeded in the ſame manner.

They are alſo a proof of the polype's arms being tubular, and that they have an open communication with the ſtomach.

The arms of the polype are of the ſame colour with its body, and an heap of the extravaſated grains before ſpoken of, are of the ſame colour alſo; it is therefore evident that the colour of the polype depends on the colour of thoſe grains which compoſe the ſkin, (for when the polype becomes white, they loſe thoſe grains) and their dependance is upon the nutritive juice, drawn from the aliments.

Theſe grains, for example, become red or black, if the polype be fed with a red or black juice; they are more or leſs ting'd with theſe different colours, in proportion to the ſtrength and quantity of the nutritive juice. It is alſo obſervable, that they loſe their colour, if not fed with aliments of the ſame colour to themſelves, and likewiſe that they will faſt a great while, but then they waſte proportionably to their faſting.

They are alſo ſubject to be infeſted with a kind of aquatic lice before ſpoken of, which are very common in expoſed waters; they are of an oval figure, and generally white; they run very ſwift upon the polype's body, and crowd about its head more than any other part, as at fig. 385. Nevertheleſs they may be ſeen in great numbers running over the body a b, and arms a c c. The preſent figure is a repreſentation of the polype and lice, as they appear in the microſcope. If proper care is not taken to keep them clean from theſe animals, they will be devoured by them, their arms will gradually diminiſh, and at laſt their body, till there is nothing left. Fig. 386. repreſents one that had all its head part eat up, which after having been cleanſed, had a new head, and new arms, and became a very fine polype.

Therefore the beſt way to preſerve theſe animals in health, is often to change the water, and that eſpecially after they have done eating, It is not enough to pour it off, but they muſt all be taken out, and the bottom and ſides of the veſſel rubbed clean from the ſlimy ſediment adhering thereto, which is cauſed by the fæces they diſgorge therein, which are converted into a kind of ſlime, fatal to them if not clear'd away, My way is to looſen their tails from the ſides or bottom of the glaſs, then I take them up one by one with a quill, cut ſcoop faſhion, and place them in another glaſs with clean water; ſometimes they cling to the quill in ſuch a manner, as not eaſily to be diſengaged. The only way then is to let the quill remain a minute or two in the water, till they diſcharge themſelves, otherwiſe you'll be in danger of breaking their arms off, however when an arm is broke, it is quickly repair'd again, but for ſome days there appears a ſwelling or calloſity in the place which wears off in time.

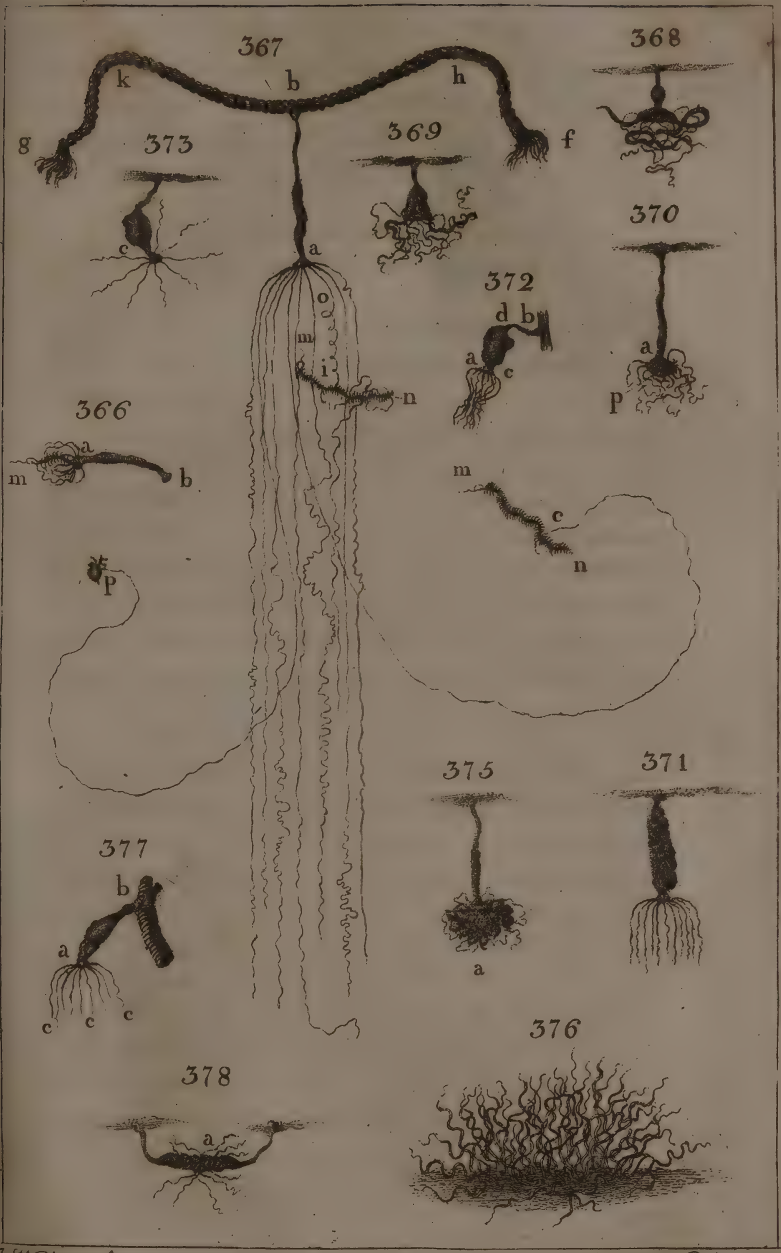
River, or any other very ſoft water, agrees beſt with them, or what is taken up clear out of ſome ditch or pond; but that which comes from a ſpring or pump, or is in its own nature hard or ſharp, prevents their thriving, and kills them in a few days.

They are beſt kept in ſuch large glaſſes as hold three or four quarts of water, for in a glaſs of this ſize, the water need not be renewed ſo frequently, eſpecially if the fæces are taken out from time to time, with the feather'd end of a pen, to which it very readily adheres. Beſides the trouble is in ſome meaſure ſaved of feeding each particular polype, for here you need only throw in a parcel of worms, and let them take their chance, but then all of them are not conſtantly fed, nor any of them ſo often as in the ſmaller glaſſes.

The worms you feed them with, muſt alſo be well cleanſed from the mud, and always remember to waſh them in clean water, every time you feed the polypes therewith.

Polypes are to be ſought for in the bye-corners of ditches, puddles, and ponds; for it is obſervable, that the wind drives them together with the plants, upon which they float into theſe places; although we may ſearch for them in ſome places without ſucceſs, yet on coming there again, they may perhaps be found in great abundance.

There are fewer of them in the waters in winter, than in the other ſeaſons. About the month of April, duckweed begins to riſe above the ſuperficies of the water



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and to increaſe, and many other plants alſo float upon the water; the warmth revives the polypes, and they fix themſelves to theſe plants in queſt of prey, at which time they may be taken out of the water with them.

Of the generation of polypes.

WHEN a young polype firſt begins to ſhoot, there only appears an excreſcence, which terminates in a point e, fig. 387.

Some time after that, when it appears cylindrical, its arms alſo begin to ſhoot at its anterior end, c, i, fig. 387. Its poſterior end is fixed to the body of its mother, and gradually grows narrower, till at laſt it only appears to adhere thereto by a point b, fig. 388. at which time it is ready to be ſeparated; which they all perform in the ſame manner. The mother and young one fix themſelves to the glaſs, or other bodies upon which they are ſituated, with their arms and head, and this is their preparative for a ſeparation; ſometimes the mother gives a twitch, at other times the young one, and often both together.

A polype a b, fig. 389. with a young one c d, ready to be ſeparated, diſpoſes of its body in an arch of a circle, a, b, d, againſt the ſides of the glaſs. The young one being faſt to the top of the arch at d, and its head fix'd againſt the glaſs; the mother only contracts her body, which by that means becomes ſtrait, as at a b, fig. 390. which was before circular. While both its extremities remain fixed againſt the glaſs, the young one, which was alſo faſtened to the glaſs, does not follow the mother when ſhe withdraws, but remains in its place, and its tail d, by this means is ſeparated from the body a b, of its mother.

Young polypes ſhoot in proportion to the warmth of the weather, and quantity of food the mother eats; ſome have been perfectly formed in twenty-four hours, and others not till the end of fifteen days. The firſt ſhot forth in the midſt of ſummer, and the other in a ſeaſon when the water in which the polype was contained, made Farenheidt's thermometer deſcend to forty-eight degrees.

They ſhoot forth from the ſide of their parent as a branch from the trunk of a tree; and the excreſcence which is the beginning of a polype, is nothing but a continuation of the ſkin of its mother, which is ſwelled and raiſed, nay even forms a tube communicating with its mother's ſtomach, as appears from the following experiment; for on chooſing a large polype of the ſecond ſort, with a young one at its ſide, which being placed upon a ſlip of paper in a little water, the middle of the young one's body was cut, and the ſuperior end of that part which remained to the mother was then open; next cutting the mother on both ſides of the young ſhoot, it became a very ſhort portion of a cylinder open at both ends, which being viewed through the ſuperior and open end of the polype, the light was ſenſibly ſeen in the ſtomach of the mother; but leaſt there might yet be a ſkin, which giving paſſage to the light, might nevertheleſs ſeparate the two ſtomachs, the remaining cylindrical portion of the mother was cut lengthwiſe, and the two oppoſite parts to that from whence the young one came out, were opened; and on obſerving it with a microſcope, not only the hole t, of communication, fig. 391, was diſtinſtly ſeen, but one might ſee quite through the end o, of the remaining portion of the young one: afterwards changing the ſituation of theſe two pieces of prepared polypes, and looking through the laſt opening e, fig. 392. the day-light was ſeen through the hole of communication i. Mr. Trembley not being contented with making this experiment once, repeated it ſeven times, and met with the ſame ſucceſs in five of them.

This communication between the mother and its young may be ſeen on feeding them; for after the mother a b, fig. 393. had eaten, the bodies of its young ones ſwelled, being filled with the aliments as if they themſelves had been eating them at their own mouths c d e i o.

In the long armed polypes, the young ones do not ſhoot out from the tail part b c, but only from the part a c, fig. 396.

It is alſo remarkable, that polypes do not only produce ſeveral little ones at the ſame time, all remaining fixed to their mother, but that even ſome of thoſe little ones at that very time have two or three young ones alſo, of which ſome are perfectly formed, as at fig. 396.

This figure is ſufficient to ſhew with what promptitude the polypes increaſe and multiply. The whole groupe formed by this mother and her nineteen young ones, was but an inch and a quarter long, and one inch broad Dutch meaſure; the arms of the mother, and the little ones, for the moſt part were hanging down towards the bottom of the veſſel, whilſt the polype was ſuſpended on the ſurface of the water. This mother eat about a dozen of the aquatic fleas every day, and the little ones, which were in a ſtate to eat, devoured amongſt them about twenty every day.

All the freſh water polypes, with arms in form of horns, are mothers, for each individual of this ſort produce young ones.

Mr. Trembley ſays, he hath nouriſhed a thouſand polypes, and never found one which did not multiply, after it had been well fed, and always obſerved their motions very attentively, in order to diſcover if nothing paſſed between them analogous to copulation in other animals; but could never find any thing like it.

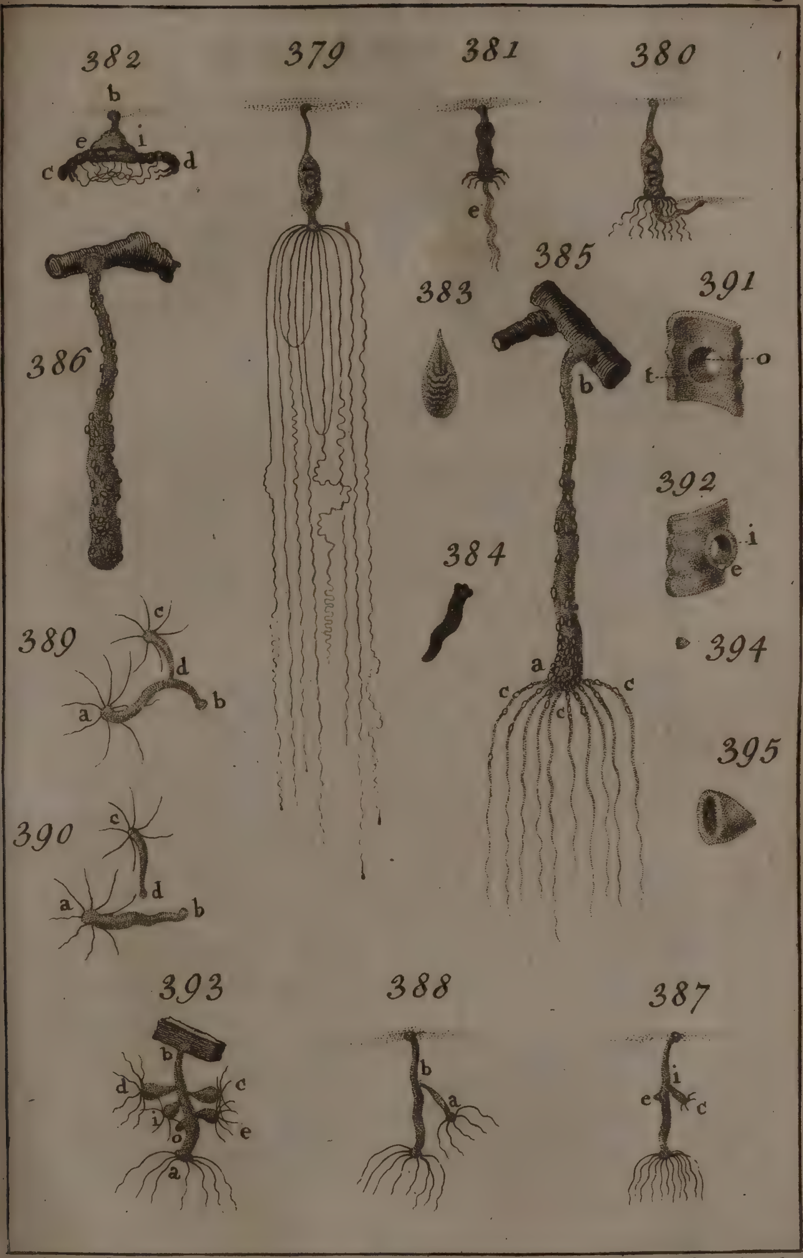
He then put ſeveral polypes of the ſecond ſort by themſelves, that he might be very ſure they had never ſince their ſeparation any communication with other polypes; and took none for theſe experiments but thoſe which he ſeparated from the mothers himſelf; or thoſe which being ſeparated of themſelves, were taken out of the glaſs in which their mothers were, before any other young one could be ſeparated, with which it might have been poſſibly coupled; yet notwithſtanding all theſe precautions of cauſing theſe polypes to live in a perfect ſolitude, they all multiplied, eat, and continued to produce young ones, more and more in proportion as they were fed.

Not only theſe which he firſt put alone have multiplied, but alſo many of their deſcendants have alſo been put by themſelves, from generation to generation, even to the ſeventh, with the ſame precautions. Whence it appears that copulation is in no wiſe neceſſary to the production of a polype.

Mr. Trembley hath alſo made an experiment to prove, that a young polype had in itſelf the principles of fecundity, before it could be thought to receive it from its mother, or any other polype: for on cutting off a young one which only began to ſhoot, and at that time was only like a little button, as e, fig. 387. it is ſeen alone and of its natural ſize after it was cut off, at fig. 394. and as it appeared in the microſcope at fig. 395. it was put into a glaſs by itſelf, and gradually increaſed, had arms, and at laſt multiplied.

It is therefore very plain, that a young polype, after being ſeparated from its mother, does not want the company of another polype to multiply.

Pl. 48



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And that even before ſeparation it hath within itſelf the principles of fecundity, ſince from that time it multiplies.

That if this principle is communicated to it by the mother while they are united, there is no ſort of communication between the head and arms of either.

Neither is there any communication after this manner by another young one, that comes from the ſame mother at the ſame time with itſelf. And that if this principle of fecundity is within itſelf, it certainly is in an imperceptible manner.

If we have not from hence diſcovered how the polypes become fruitful, we have at leaſt learned, that in this point they differ from the moſt part of known animals, and by conſequence have made an exception to the general rule, that ſays, there is no fecundity without copulation.

After Mr. Trembley had made the foregoing obſervations, he was ſtill farther deſirous of finding out, whether there might not be ſome other natural manner of their multiplying by ſlips, as the branches of a tree; or if, on the contrary, this manner of multiplying would ſucceed when they are cut in one or more parts. Mr. Trembley hath ſeen polypes which have divided themſelves into two parts, after which each portion became a compleat polype; whereby the ſame re-production was performed as we have before remarked on cutting theſe animals in two.

What hath been already ſaid on this head is ſufficient to ſhew, that polypes bear a nearer reſemblance to plants than animals, yet notwithſtanding it is evident that they are animals, becauſe they eat and digeſt their food.

Of cutting polypes aſunder, and their reproduction.

THE moſt extraordinary part in the hiſtory of this creature is this, that when cut into pieces each piece can repair itſelf and become a perfect animal [p].

To perform which put a little water on a ſmall piece of paper, whereon place a polype, and wait a little while till it extends itſelf; then with a pair of ſharp ſciſſars cut it into two pieces, paper and all, and examine each piece with a magnifying glaſs, to judge the ſucceſs of the operation, putting each portion into a ſhallow glaſs which does not contain above three or four tenths of an inch in depth of water, by which means they may be always obſerved with a magnifying glaſs, or in the microſcope.

A, fig. 397. repreſents the head part of a cut polype, its poſterior end b, being a little larger than that in a common polype, and is ſenſibly open. In the ſummer-time this firſt part often walks, and eats the ſame day it is cut.

The ſecond part, fig. 398. hath its anterior end c more than ordinary open, and the edges turned a little outwards, which afterwards folding inwards, cloſes the aperture: the anterior end appearing then to be ſimply ſwelled, as at c, fig. 399. This part is never ſeen to change its place before its re-production is finiſhed; the arms ſhot out from its anterior end as thoſe do in young polypes, at firſt three or four points begins to ſhoot, as at c, fig. 400. and while theſe increaſe, others appear between them; before the arms have done growing they can ſeize a prey, and from that time its mouth is perfectly formed.

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[p] Hiſt. de Polype, p. 193.

This re-production is performed ſooner or later, as the weather is more or leſs warm. In the height of ſummer the arms will ſometimes begin to ſhoot in twenty-four hours, and in two days have been in a ſtate to eat, but in cold weather it will be fifteen or twenty days before the head is formed.

If a polype, having young ones, be cut tranſverſly, the young ones continue to grow after the ſection.

It often happens, that the ſecond parts which have had no young ones at the time of the ſection, have had young ſhoots before itſelf could eat, and before it had arms.

In whatſoever place a polype was cut, whether at the middle or near either end, the experiment equally ſucceeded, and each portion became a compleat polype, which walked, eat, and multiplied.

A polype being cut cloſe under the arms, as at fig. 401. and though ſmall as it was, it became a compleat polype, which at the beginning was all arms.

If a polype be cut tranſverſly into three or four pieces; the poſterior end of the firſt produces a tail, the anterior end of the laſt a head, and the intermediate pieces acquire both head and tail.

To cut a polype lengthwiſe, it muſt be made to contract as much as poſſible, becauſe the more it is contracted the larger its body is: therefore put the polype upon a ſlip of white paper in a ſmall drop of water, and when by touching it is very much contracted, drain away the water, whereby its upper and under ſides colapſe, and the polype becoming ſpread in breadth, remains fixed upon the paper; then with a ſharp pair of ſciſſars cut through both paper and polype, the divided parts will adhere to the paper like a jelly, but may be removed therefrom to the object-carrying glaſs, or glaſs ſlide, with

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the point of an hair pencil, firſt dipped in water, upon which it may be applied to the microſcope; or if the papers are thrown into a glaſs of water, the divided pieces will ſoon fall from them.

The ſides of a polype cut longitudinally, roll themſelves up different ways, generally beginning from one of their extremities, as at fig. 402. and turns the out-ſide of the ſkin inwards; after ſome time it unrolls, and the out-ſide forms itſelf into a tube, whereof the edges a b, and e i, fig. 403. on both ſides meet each other, and reunite themſelves; ſometimes they begin to join at the tail end, at other times they gradually approach all at once; when they begin to unite at one end, it is eaſy to diſtinguiſh that portion which is joined c i b, from that which is not joined c a e, fig. 404.

The ſides join ſo cloſe, that from the firſt moment no ſcar can be ſeen; after which they become compleat polypes, but with a leſs number of arms, and that in an hour's time, and in twenty-four hours will ſeize and devour a worm; in a few days other arms ſhoot and become as long as the reſt.

Mr. Trembley cut a polype into four parts length-wiſe, as follows: after having cut it in two, in the manner juſt ſhewn, he cut each of theſe into two alſo. Theſe four portions of the ſame polype, had each of them ſix arms, within ſix days after the ſection; and ſeven in four weeks; they all eat and multiplied.

When a pregnant polype is cut length-wiſe, the young ones continue to grow after the ſection.

He hath alſo cut a polype length-wiſe, and directly after cut the ſame tranſverſly, and each of theſe four quarters became compleat polypes.

He

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[s] Hiſt. de Polype, p. 247.

He likewiſe cut another, in part length-wiſe, beginning at the head, which became a polype with two bodies, two heads [q], and but one tail. After having nouriſhed this two headed polype, by feeding it at both mouths; he alſo ſplit theſe heads, and in a little time it had four, and at laſt by cutting it after the ſame manner, it had ſeven heads, fig. 405.

If a polype be cut in part length-wiſe, beginning at the tail, it will ſoon have one head and two tails; and in this manner the number of heads and tails may be augmented by cutting almoſt ad infinitum.

As all ſorts of theſe freſh water polypes form only a tube or gut, proceeding from one of its extremities to the other, they may be turned inſide- out as one would turn a ſack, viz. give a worm to the polype you would perform this experiment upon, and when it is ſwallowed, put the polype into a concave glaſs, or into the hollow of the object-carrying glaſs, with a little water; afterwards preſs it near the tail with an hair pencil, ſtroking it towards the polype's mouth, that the worm within its ſtomach may be forced partly out, as at c e, fig. 412. its hinder part a, remaining empty. As the worm goes out, the ſtomach enlarges prodigiouſly, eſpecially if it goes out double, as is expreſſed in the figure. When the polype is in this ſtate, make it contract as much as poſſible, which contributes much to the enlargement of the ſtomach. It muſt be here obſerved, that as the worm is partly out of the ſtomach it keeps it open, then taking an hog's briſtle in the right hand, puſh it againſt the extremity of the tail b, till it enters into the ſtomach, continuing gradually to advance the hog's briſtle, till it hath quite turned the polype. When it comes to the worm which keeps the ſtomach and mouth open, it either puſhes that out, or paſſes by on one ſide thereof, and at laſt goes out of the mouth, as at a b, fig. 414. Sometimes the polype is entirely turned at firſt, and then it covers the end of the briſtle a b, fig. 413. In this caſe the exterior ſuperficies of the polype is become the interior, which now touches the hog's briſtle; however it ſeldom happens that the polype is entirely turned, but moſt commonly the tail part a b is out of the mouth b, fig. 414. and at the ſame time a part thereof is not turned; that is, its anterior end a c, which being terminated by the arms, is folded over the turned end. Then to finiſh the turning, take an hair pencil in your right hand, and the end of the hog's briſtle in the left. Always holding the other end of the briſtle together, with the polype in the water, and ſtroke the end a c, which is not turned, very ſoftly with the hair pencil, that way which is neceſſary to turn it, that is to ſay, from a to c, fig. 414. which is preſently performed, at which time it appears as at a b, fig. 413. Then holding it in the water, puſh it from a to b, with the point of an hair pencil, and it will fall to the bottom of the glaſs without being put out of order.

When it is firſt turned, the mouth cloſes, and the lips a, incline a little inwards; the arms a c appear to join in a bundle, and to come out of the middle of the polype's mouth, as at a, fig. 415.

After the polype is turned, extend it as much as poſſible with the hair pencil, then taking an hog's briſtle with a knot near one end thereof, run the other end through the polype's body, near its lips; at that inſtant let the other end of the briſtle e, drop into the water, and with the point of the pencil, puſh the polype to the middle a, of the briſtle, fig. 416. then take out the briſtle and polype, and put them into a glaſs, f, e, g, h, taking care that it only touches the glaſs by its two extremities c and d, that the polype may be a great way from the bottom and ſides thereof, and the knot end towards the bottom; that if the polype ſhould ſlide by its own weight, it might not be able to diſengage itſelf. This method is uſed to prevent the polype from turning itſelf back into its natural ſtate, which they ſometimes do in twenty-four hours after they have ſuffered this operation; and often after they have been turned, and ſpitted, to prevent them from returning, they have tore their lips, and by that means have formed two heads.

Several young ones have been produced from theſe turned polypes, which have alſo multiplied.

Sometimes they will eat in two days after they have been turned, but generally not till four or five days after.

Moſt of thoſe Mr. Trembley turned, endeavoured to return themſelves again, but could not entirely effect it, remaining like a polype partly turned, as at fig. 406. the ſkin of its anterior part being applied upon the other, and forming a kind of pad at the anterior end a c, one part thereof being turned, and the other not. Its lips a, are no more at the anterior end, but are round that part of the body which is not turned back again, from whence alſo the arms proceed, varying their direction, ſometimes pointing towards the tail, fig. 406. and at others are bent over the head, fig. 407. their anterior extremity c, fig. 406. formed by the edges of the reverſed part c a, remained open, and ſome days after began to cloſe; and on being attentively obſerved, new arms began to ſhoot near the old ones, and ſeveral mouths [1] were alſo formed near the middle of the bodies of theſe polypes, that is to ſay, near the place where their arms joined the body at a, fig. 406.

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[1] Hiſt. de Polype, p. 268.

A polype partly turn'd back again, remains but a little while in that ſituation, as at fig. 406. The place a, to which this return'd portion a c, was fixed to the other part a b of the body, became a little ſtreighten'd, and the portion a c, formed a right angle therewith, as is ſhewn at fig. 408. where a c repreſents the returned portion, and a b the other part of the body; the ſame day another head appear'd at e, and ſeveral arms began to ſhoot, on one ſide a o, of one mouth, a o n, which was formed on this ſide; the other ſide a n of this mouth, being border'd by part of the old arms a d, a d. Next day the lips of the new mouth was diſpoſed in form of a conical nipple, and the new arms ſmaller than the old ones. The ſame day the returned portion a c, fig. 408. which the day before made the right angle c a b, with the other part a b, not returned, was drawn nearer to this laſt part, and made an acute angle therewith, as at fig. 409. where a c repreſents the returned portion, and a b that portion not returned. The doubtful part e, remain'd as before; a worm being given to it, fell upon the old arms, was ſeized, conveyed to the new mouth, and ſwallowed in an hour's time, and the portions a c, a b, and a e, fig. 409. were ſwelled with the contents of the worm.

Four days after, its form was much different, as appears by a compariſon of the figures 410, and 411, whereof a c, repreſents the returned part, and a b, the part not returned. Having now but one common mouth a, fig. 410. the new arms are ſeen between a and t, the equivocal part e as in the figures.

This form was changed but little in fifteen days, as is ſeen on comparing the two foregoing figures; the old arms which were before between a and t being vaniſhed, and a head at u, fig. 411. which was at firſt taken for

a

a young one, but remain'd in the ſame ſtate above three months. This polype had two young ones, which proceeded one from g the returned part, and the other from f, the portion not returned.

Theſe obſervations are ſufficient to ſhew the nature of a polype that is partly turn'd back again, and the different revolutions made in theſe animals, are ſeen in the figures 406, 408, 409, 410, and 411. which repreſent the ſame polype, and the return'd part always a c, and that part not returned a b.

Theſe changes are not exactly the ſame in all polypes, but vary conſiderably, ſeldom any two of a great number being perfectly alike.

The polype repreſented by fig. 417. was turn'd, and the following day returned part of its head, as at fig. 407. which ſeven days after was formed into three heads, as at fig. 417. a b, ſhews the tail of the polype, which remain'd turned. a d c g e, the portion turn'd back again ſo conſiderably changed as to form three heads d g e.

Fig. 418. exhibits the ſame polype fourteen days older, a b the portion which remain'd turn'd, a d c n g e o, the portion turn'd back again, a d, n g, n e, its three heads and necks; marked d, g, e, in the foregoing figure.

Fig. 419. is the ſame polype thirteen days after it was in the ſtate of fig. 418. The portion o c of fig. 418. is parted from o to c, and the two portions, b a c d o, and c n g e o, fig. 419. are only faſtened to each other by a thread o, a b, is the turned portion, a c and o c two portions, which in the preceeding figure are re-united, and marked o c, a d, n g, n e, and are the three heads with necks, and are marked by the ſame letters, fig. 418.

The two portions held by the thread o, fig. 419 are ſeen as they were ſeparated in fig. 420 and 421. a b, fig. 420.

420. is the turned part, and a d one of the heads, n g, n e, fig. 421. the two other heads.

Mr. Trembley imagined, that if one polype could be put in the ſtomach of another, in ſuch a manner, that the external ſuperficies of the ſkin of the firſt, ſhould be applied to the internal ſuperficies of the ſkin of the ſecond, they might ſtick together, and become but one polype.

To introduce one polype into another, firſt feed ſome of them, and when they are ſwelled by the aliments, their mouths will be alſo extended. Take that polype out of the water, you would introduce into the ſtomach of another, and put it upon your left hand, making it contract as much as poſſible by ſtroking it with an hair pencil, in ſuch a manner as to force the aliments out of its ſtomach, and thereby cauſe its mouth to open; then taking a hog's briſtle in the right hand, put the biggeſt end thereof into the polype's mouth, and thruſt it to the bottom of its ſtomach. When this is done, place the polype upon your hand, into which this is to be introduced, cauſing it to open its mouth, as in the other polype, and thruſt that which is upon the hog's briſtle, into the ſtomach thereof, and dip it into a glaſs of clean water, that you may examine it with a magnifying glaſs; then to prevent the inner polype from extricating itſelf, ſpit them both together upon an hog's briſtle.

Fig. 422. repreſents two polypes put one into the other, a b the exterior polype, and c a, b d, the interior one; e f in all the figures ſhews the hog's briſtle which run through both the polypes at e.

Fig. 423. is the ſame polype, a i b the exterior one, c a i d the interior one; the part i d by bending having ript up the part i b of the exterior polype, and by this means got out.

Fig. 424. ſhews the ſame two polypes, whereof i d, of the interior, tore the part i b of the exterior one farther up, even to e; where the briſtle at firſt ran through both the polypes together: but when in the ſtate repreſented by this figure it pierced the interior one c a i d at e, and the exterior one a i b at i.

Fig. 425. repreſents the ſame two polypes after the anterior one a e b, had tore up the lips of the exterior one, c e d, and came out therefrom; they were ſeparated in a few days, and both of them did well.

Mr. Trembley hath given us a curious drawing of an aquatic animal which he calls a plumed polype; it is repreſented as they appear in the microſcope at fig. 426. The plume and length of its body taken together are about two twelfths of an inch in length, its body very ſmall, almoſt cylindrical, and ſkin perfectly tranſparent. The plume is a continuation of this tranſparent ſkin, very large in proportion to its body, and of a very remarkable figure.

Its baſe e a c is in the form of an horſe-ſhoe, from the edges of which proceed the arms a d, a d, a d, whoſe extremity is a little turned outwards, and are ſo cloſe together, that the plume contains 50 or 60. The baſe e a c of this plume ſerves the animal for a mouth; its inteſtines may be diſtinctly ſeen through this tranſparent ſkin at e b, f g, f a, and are of a brown colour; after the animal hath eaten, three principal parts of their inteſtines are viſible, the gullet e b, the ſtomach f g, and the ſtrait inteſtine f a.

Theſe animals withdraw themſelves into a caſe i, k, l, B, I, m, that ſeems to be compoſed of the ſame tranſparent matter with the ſkin of the body, which is faſtened by its inferior extremity i b, I B, to the orifice of the caſe; ſo that whenever the animal retires into the caſe, the ſkin of the body is reverſed. The plume which is upon the baſe c, enters with it, and appears, when all incloſed, like A B. After it is thus incloſed, it will ſoon come out again if it be left quiet.

When it is out of the caſe, you may ſee a tendon fixed by one end g, to the inferior extremity of the ſtomach; and the other at o, the bottom of the caſe. There is alſo another of theſe tendons fixed to the baſe of the plume at a, and the other end of the ſame to the bottom of the caſe at o; it is by the help of theſe two tendons that the animal draws itſelf into the cell.

Theſe plumed polypes are ſeldom alone, but many of them placed together one by the ſide of the other; and there are ſeveral of them that come out of the ſame caſe, but by different orifices, which is the way they multiply.

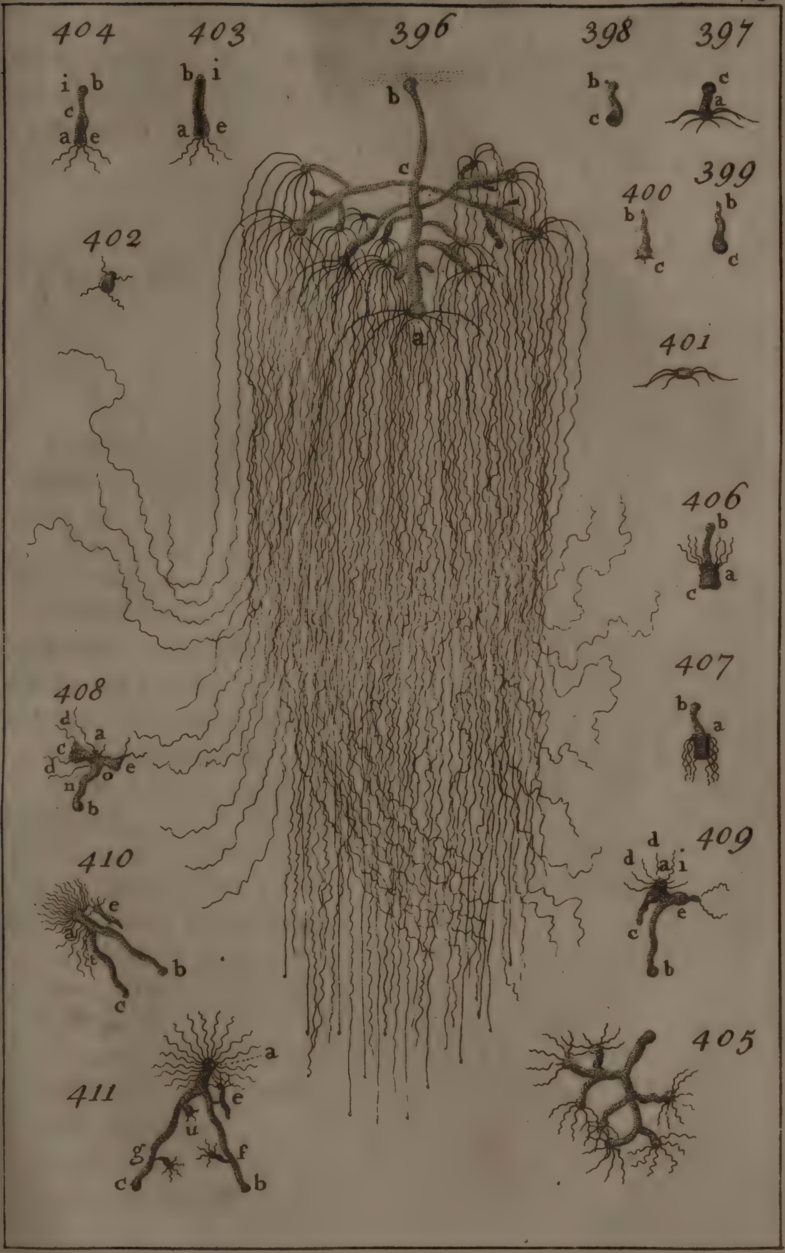
At firſt there is a little elevation upon the ſuperficies of the caſe of an old one, after which the body and plume s t begin to appear; or when a young one begins to ſhoot the baſe of the plume and points of its arms u u u, ſhew themſelves and increaſe as the body enlarges.

They can only eat very ſmall animals, but of theſe they devour great numbers in a day.

The quick motion of the plume, or rather the feather-like arms thereof, form a kind of whirlpool, into which moſt of theſe little animals that are ſwimming near it are precipitated.

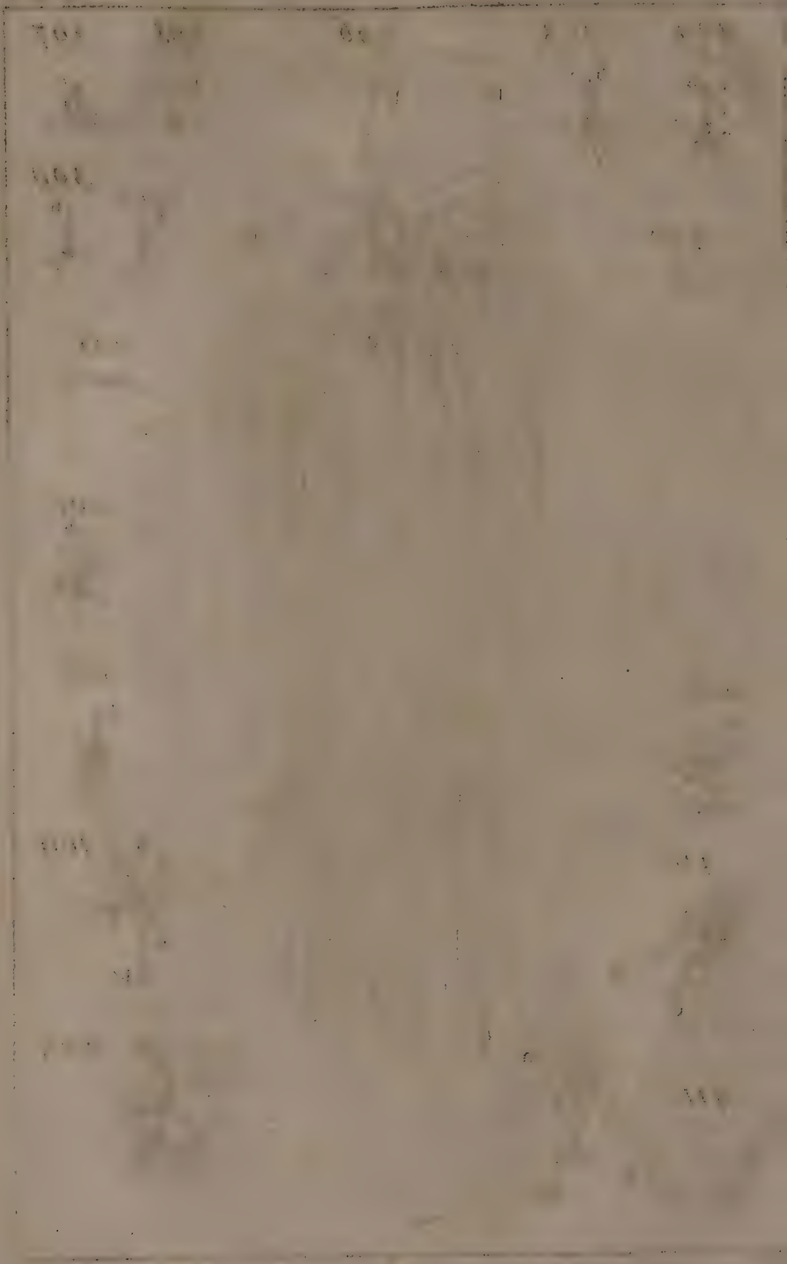
Every inſtant one or two of its arms ſuddenly bend into the plume, and immediately replace themſelves into their firſt ſituation; the ſame arm ſeldom bends twice together, nor do they touch the prey but by their rapid and continued motion cauſe a turning in the water, which conducts thoſe minute animals into the plume, although they make ſeveral efforts to eſcape, the ſudden inflection of one arm, adds a new degree of rapidity to the

Pl. 49.



Front.^g Pag. 208.

Bowles sc.



the torrent which hurries them into the plume, where they are immediately ſwallowed, by the mouth which is in the midſt thereof.

Of vegetables.

THIS ſeemingly inferior branch of the creation, when carefully attended to, by the aſſiſtance of the microſcope, exhibits to us an ample ſcene of the creator's wiſdom, curioſity, and art, in the wonderful contrivance even of the moſt abject vegetables, but more eſpecially in the anatomy of them; wherein may be ſeen the admirable proviſion made for the conveyance of the lymphatic and eſſential juices, in communicating the air, as neceſſary to vegetable as animal life, and more particularly in the generation and make of the ſeed, wherein the lineaments of the parent vegetable are incloſed in miniature; and wherein alſo we ſee that God Almighty has by one act of his creating power provided for all ſucceeding ages; and the future poſterity of each ſeed does of neceſſity produce its own reſemblance: for the preſervation of which, nature hath endow'd ſome with light downy wings, to be conveyed about by the winds; others are laid up in elaſtic ſpringing caſes, that upon burſting dart their ſeed at convenient diſtances, and others, &c. are planted by the induſtry of the huſbandman.

The ſeeds of plants are incloſed in different ſheaths or caſes, till they are lodged in the earth. Some are depoſited in the very heart of the fruit, as the kernels of apples and pears, others grow in cods or ſhells, as peas, beans, lentils, poppy ſeeds, and cocoa nuts; ſome in wooden ſhells, &c.

The farina of flowers appears to the naked eye a kind of mealy powder, which is found on the pendant tops of

almoſt

almoſt every flower; its colour various in different flowers, but its ſtructure conſtantly the ſame in plants of the ſame ſpecies. Here alſo the microſcope hath diſcovered ſurprizing beauties, and hath ſhewn us, that this powder is produced with the utmoſt care in veſſels wonderfully contrived to open and diſcharge it, when it becomes mature, and that there is a piſtil, ſeed-veſſel, or uterus, in the center of the flower, ready to receive the minute grains of this powder, either as they fall of themſelves, or are blown out of their little cells. We are alſo taught by experience, that the fertility of the ſeed entirely depends on this; for if the farina veſſels are cut off before they open and ſhed their powder, the ſeed is unprolific [*].

Of ſeeds.

THE ſeed is the laſt product of a plant whereby the ſpecies are propagated; it is frequently the fruit of the plant, as is the caſe in moſt herbs: ſometimes it is only a part incloſed in the fruit, and that in form either of grain, kernel, or berry.

It is the natural offspring of the flower, and that for whoſe production all the parts of the flower are intended; ſo that when this is once well formed, the ſeveral parts of the flower dwindle and diſappear.

It is produced from the farina of the apices let fall on the head of the piſtil, and thence forwarded to an uterus at the bottom thereof, divided into ſeveral cells; where coming to receive the nutritious juice of the plant, it is firſt ſoftned, then ſwelled, increaſed both in matter and bulk, and at length comes to its ſtate of maturity.

By

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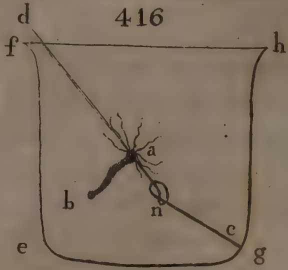
[*] Phil. Tranſ. No. 207.

416



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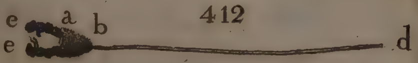

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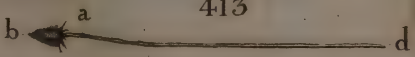

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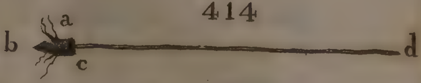

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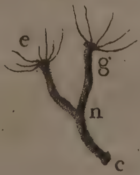

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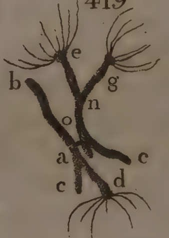

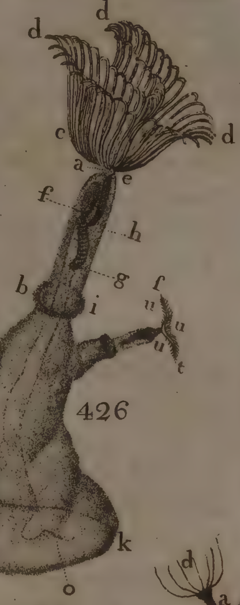

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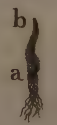

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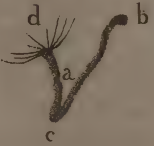

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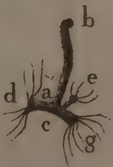

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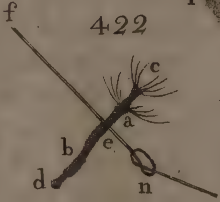

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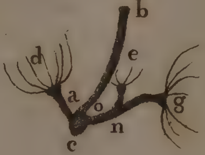

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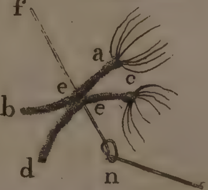

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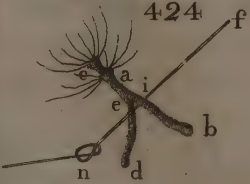

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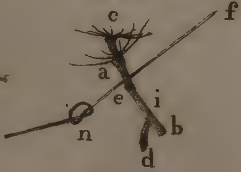


By the uſe of the microſcope we diſcover in the ſeed ſeveral parts of the future tree, only in miniature; particularly a little root called the radicle, and the ſtem called the plumule.

I ſhall exhibit the curious and gradual proceſs of nature in the vegetation of the ſeed; and firſt, in that of the garden bean, repreſented by fig. 427. by which a general idea of all ſeeds may be eaſily formed. It hath a ſmall hole at a, that upon diſſection is found to terminate againſt the ſtalk of the plumule; its end is apparent at a, in the tranſverſe ſection of the bean, fig. 428. in which figure the ſeveral coats of the bean appear, the innermoſt is every where twice, and in ſome places thrice as thick as the outermoſt; and where it ſurrounds the ſtalk of the plume, it is ſix or ſeven times as thick, as may be ſeen at b, fig. 428.

The hole a, fig. 427. is not caſually made by breaking off the ſtalk, but deſign'd for the nurture of the young plant, and may be ſeen in ſeveral other kinds, as peas, vetches, french beans, lupines, lentiles, &c. in other ſeeds alſo, medica tornata, fænugreek, goats-rue, &c. in ſeveral of theſe it is not diſcernable without the aſſiſtance of the microſcope; and in ſome not without cutting off part of the ſeed. When any of the above-named ſeeds have been ſoaked in water, ſeveral bubbles will alternately break through this hole on their being ſqueezed. All ſeeds having thick and hard covers, are alſo perforated in the like manner; and thoſe lodged in ſtones and ſhells, though not viſibly perforated, yet the ſtones and ſhells themſelves always are. When the coats of the bean are ſtripped off, the ſeed appears; its main body is divided into two lobes, joined together at the baſe of the bean, as at fig. 429. In young beans, eſpecially if boiled, theſe lobes eaſily ſlip aſunder; but in dry beans are very difficult to be ſeparated, unleſs they be firſt macerated ſo twenty-four hours in water. Some few ſeeds are divided into more lobes, as the creſſes into ſix, and ſome not at all, as grains of corn, &c. moſt other ſeeds, even the ſmalleſt, are divided exactly into two lobes like the bean; that which joins the two lobes together is called the ſtem or radicle, out of which the root is formed when the ſeed vegetates. This ſtem is found in all ſeeds; in the bean and ſeveral others, it is ſituated ſomewhat above the thick end, in oak kernels, commonly called acorns, apple-kernels, almonds, &c. it ſtands prominent juſt from the end.

The plume or bud iſſues out of this ſtem, and is that which afterwards becomes the trunk of the plant, ſeparable in ſeveral already formed, though not diſplayed, leaves, which appear upon the ſprouting of the ſeed, and may be ſeen in the ſeed itſelf by the aſſiſtance of the microſcope.

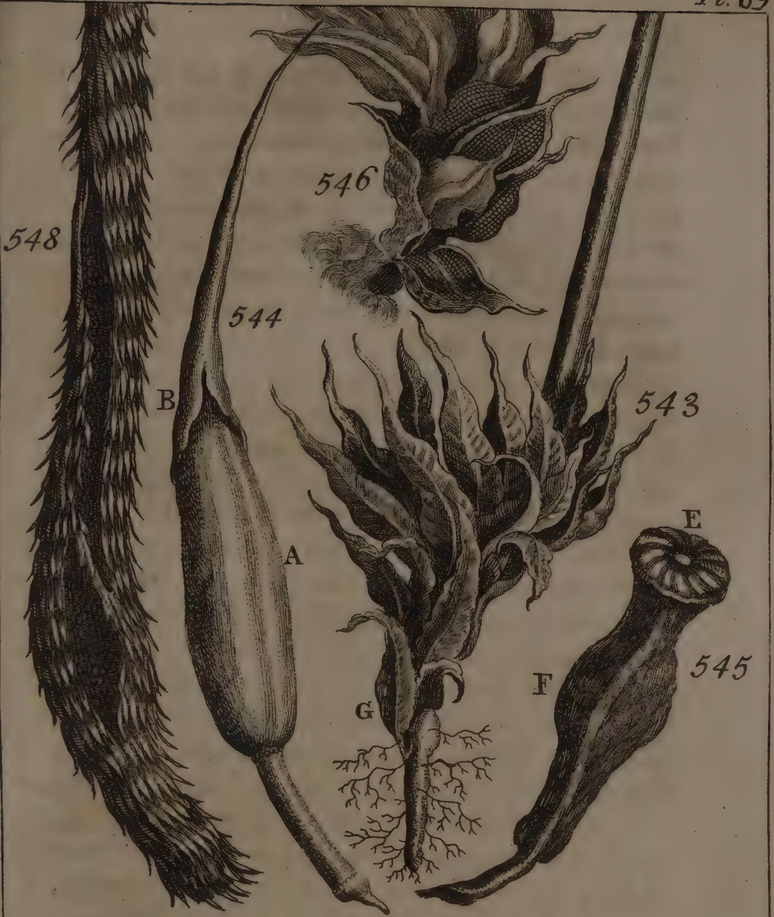
The plume is incloſed in a cavity formed in the lobes on purpoſe for its reception, which may be ſeen at b, fig. 429. it is almoſt of the ſame colour with the radicle, or little root, on the baſis whereof it is ſuſtained.

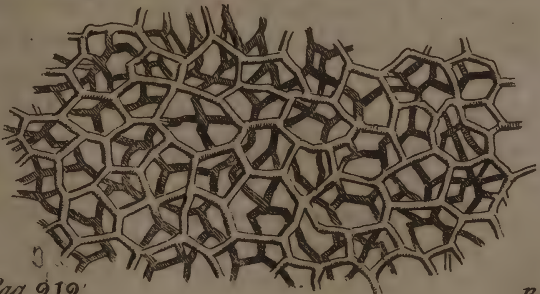
It is the firſt part that appears out of the earth; as in effect it is the firſt part that appears out of the membrane, or cover of the ſeed, there being a hole over againſt it in the membrane, through which it makes its eſcape.

It is the appearance of the plume without the cavity of the grain, that makes what we call the bud or germ of a plant.

In diſſecting a bean, if you hold your knife aſlope, and very gently bear upwards, an exceeding thin and tranſparent ſkin will ſhew itſelf, juſt as the knife enters; this ſkin is not only ſpread over the convex of the lobes, but alſo upon the flat thereof, and is extended both upon

Pl. 69.





Front.^{9} Pag. 212

Bowles ſc.

the radicle and plume, and ſo all over the bean. This fine ſkin vegetates imperceptibly, and the two extremities of the bag, which ſurround the head of the bud, expand and riſe with it in order to preſerve it from all ſuch frictions as may injure its tender and delicate texture [t]. Next to this is the parenchyma, conſiſting of an infinite number of extremely ſmall bladders, which may be ſeen in a very thin ſlice of a bean when applied to the microſcope, and appears like pith while ſappy in the roots and trunks of plants; on cutting the radicle tranſverſly in ſeveral parts, another body of a quite different ſubſtance from the parenchyma or pulp, will be found, which is alſo conſpicuous in a tranſverſe ſection of the lobes, and appears there like ſeveral ſmall ſpecks, and of a different colour from the pulp: theſe are the ſeveral branchings of the tubes proceeding from the radicle, and forming but one intire trunk till it riſes to a b, fig. 430. from whence it iſſues forth into three main branches, the middlemoſt directly into the bud c, and the other two after a little ſpace, paſs from e e on either ſide into the lobes, where they divide into ſmaller branches, and theſe again ſpread into other more minute ramifications, and terminating near the verges of each lobe, become a perfect root.

This ſeminal root being ſo tender, is difficult to be diſcovered, but may be come at by a careful paring off the parenchyma in thin ſlices lengthwiſe, in new beans; or if old beans are ſoaked a conſiderable time in water, the ſame may be effected.

The ſpecks that appear on cutting the radicle and plume tranſverſly, are moſt viſible in the bean and great lupine.

The ſeminal root hath not yet been diſcovered in apples, plumbs, nuts, &c. partly from their colour, being the

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[t] Grew Ana. Plant. p. 4.

ſame with that of the pulp, yet in the gourd ſeed the main branches with their ſeveral ramifications appear immediately on ſeparating the lobes.

The parenchyma of the lobes is a kind of meal intermingled with a nutritious juice, or ſap of the earth, forming a kind of pap or lacteous ſubſtance, which being filtered through the ſeveral branchings of the ſeminal root, are conveyed through the two ſmall tubes a and b, fig. 430. into the bud, which is gradually repleniſhed therewith. When theſe ſeminal roots have communicated all the nouriſhment of the lobes to the young plant, they begin to wither, together with the ſkin that covers them; the ſtem or radicle then alſo begins to take root in the ground for its future ſubſiſtance.

The coats of the ſeeds.

HOW it was in its ſtate of vegetation hath juſt been ſhewn; it remains then to inquire into its ſtate of generation; for what in the other ſtate was not apparent, or intelligible, will in this occur; and here alſo we ſhall find a large field for the employment of the microſcope.

The two general parts of the ſeed are its covers and body. The covers in this ſtate are uſually four; the outermoſt, which is called the caſe, and is of various forms, ſometimes a pouch, as in naſturtium, cochlearia, &c. a cod, as all pulſe; ſometimes parted as ſorrel, knotted graſs, &c. The two next are properly the coats, in a bean eſpecially, and the like; from whence the denomination may run to the correſponding covers of other ſeeds; their figures are ſometimes kidney'd as alcea, behen, poppy; triangular, as polygonatum, ſorrel, &c. ſpherically triangular, as mentha, meliſſa, &c. circular, in leucoium, amaranthus; globular in napus, aſperula;

oval in ſpeculum veneris, tithymalus; ſemi-globular in coriander, ſemi-oval in aniſe, fennel, pirimidal in geranium, althææfol, with many other differences.

Sometimes gliſtering, as in Venus looking-glaſs, rough caſt in catanance, ſtudded in behen, blataria; favous in papaver, antirrhinum, lepidum, annum, alcea-veſicaria, hyoſcyamus and many more, [u] before the ſeeds have lain long by; pounced in phalangium cretæ, lithoſpermum; ramified in pentaphyllum fragiferum erectum majus, reſembling the fibres of the ears of the heart.

All ſeeds have their outer coats open, as in beans and pulſe, as before ſhewn, or elſe by breaking off the ſeed from its peduncle or ſtool, as in cucumber, chicory, &c. or by the paſſage of a branch or branches, not only into the concave near the cone or top of the ſeed, but through the cone itſelf.

The fourth or inmoſt cover, is called the ſecondine, a ſight of which may be obtained by cutting off the coats of an infant bean in very thin ſlices; at the cone thereof, if not broke, it is tranſparent; if torn, it gathers up into the likeneſs of a jelly. In large old beans it is not to be diſtinctly ſeen, but in moſt ſeeds it may, even when full grown, as in cucumber, colocynthis, burdock, carthamum, gromwell, endive, mallows, &c. though in theſe it is generally thin and difficult to be diſcovered, yet in ſome kernels, as apricocks, it is very thick, and remarkably ſo in ſome other ſeeds.

The concave of this membrane is filled with a moſt tranſparent liquor, out of which the ſeed is formed, as appears on cutting an infant bean, or better in a young walnut.

Through this membrane, the lignous body, or ſeed-branches, in the inner coat, ſhoot down in two ſlender fibres;

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[u] Grew. An. Plants, p. 45.

fibres, near the baſe of the radicle, one into each lobe of the bean, and there ſpread into a great many ramifications, which convey the juices on the vegetation of the ſeed, into the radicle and plume, as before deſcribed.

Of the ſeed caſes or membraneous uterus.

THE ſeed caſe is a kind of fleſhy uterus, growing more moiſt and pulpy as the ſeed ripens, but the caſe itſelf whether called cod, pod, or by any other name, is a membraneous uterus, which grows more dry and hard as the fruit ripens. In ſome the ſeed caſe is originally open, in others it opens when the ſeed is ripe, and in others not at all till the ſeed is ſown.

Garden radiſh-ſeed breaks within as it ripens into ſeveral white dry membranes, round about the ſeed. Near the ſides of the caſe run a pair of vaſcular fibres, from which branch forth ſeveral ſmaller fibres, ſome towards the ſides of the caſe for their ſupport, and others towards the center thereof upon which the ſeeds hang, fig. 431.

Of thoſe which open as ſoon as the ſeed is ripe, ſome open at the top, as poppy heads, fig. 432. others on the ſide, as moſt cods; and ſome at the bottom as codded arſmat, fig. 433. the poppy head is divided by eight or ten partitions into as many ſtalls, and on both ſides the partitions hang a moſt numerous brood of ſeeds.

Of thoſe which open on the ſide, ſome open on one ſide, ſome on both, others with three ſides, ſome more, and others horizontally, or round about.

The cod of a garden bean opens on one ſide, and hath a two-fold parenchyma; in the outermoſt ſtands all the veſſels in ſeveral parcels, from one of which, being larger than the reſt, and at the back of the cod, ſhoots forth theſe leſſer veſſels whereon the beans grow; the inner pulp is wholly compoſed of bladers, in which many of thoſe threads whereof the bladders are wove, are ſo looſe, as to be eaſily drawn out to a conſiderable length, and are very viſible when applied to the microſcope.

The ſeed caſe a b c d, of yellow henbane, fig. 434. opens on both ſides, from its top at a, grows a ſtem, which diminiſhes as the caſe ſwells, and at laſt falls off. On the ſides of the caſe run two oppoſite vaſcular fibres, and as the caſe gradually increaſes, it as gradually ſeparates on both ſides in the tract of the aforeſaid fibres as at b. The caſe is lined with a ſmooth thin ſkin, in whoſe center is a great parenchymos boſs c, being the bed of the ſeeds which lie all over as in a ſtrawberry; throughout this bed the veſſels d, for the generation and nouriſhment of the ſeed, are diſtributed, as may be ſeen in the tranſverſe ſection thereof at d, in which a very ſmall fibre, ſhooting from the direct fibres obliquely into each ſeed, is plainly viſible.

The ſeed caſe of a tulip, whereof a, repreſents the caſe intire, b is a tranſverſe ſection of it, and c the caſe ſplit down. Fig. 345. it opens on three ſides, from the midſt of each proceeds a partition, all meeting in the center of the caſe, and making ſix diviſions for the ſeed. The veſſels are curiouſly diſpoſed after they riſe above the ſtalk, being at firſt divided into three principal branches, running along the three angles of the caſe, from which divers leſſer branches tend horizontally, and meet at the middle of each ſide; whence they proceed through the breadth of each partition to their edges, in the center of the caſe, where they are again diſtributed into very fine and ſhort threads, whereon the ſeeds hang.

The ſeed of anagallis or pimpernel, fig. 436, is a little globe opening horizontally into two hemiſpheres, the uppermoſt falls off when the ſeed is ripe, and ſo the wind ſows them.

The ſeed-caſe of codded arſmat, fig. 433. neither opens at the top nor on the ſides, but at the bottom, being compoſed of four ſides; in the center of the caſe, is a column a, upon which the ſeeds hang looſely. From this mechaniſm that violent ejaculation of the ſeed is intelligible, which is not a motion in the ſeeds themſelves, but contrived by the ſtructure of the caſe, the ſeeds hanging very looſely, not on the ſides of the caſe, but on the ſtem in the center thereof, with their thickeſt ends downwards, ſtanding ready for a diſcharge; the ſides of the caſe being lined with a ſtrong membrane, they perform the office of ſo many little bows remaining faſt at the top b, are let off at bottom, and forcibly curl upwards and drive all the ſeeds before them.

Of the number and motion of ſeeds.

NAture hath procured the propagation of plants ſeveral ways, but chiefly by the ſeed; for the production of which the root, leaves, flowers and fruit do all officiate; and according as the plant or the ſeed it bears is more or leſs liable to be deſtroyed, proviſion is made for the propagation of either by a greater number of ſeeds, or otherwiſe; for inſtance, the ſeeds of ſtrawberries being gathered, or eaten by vermin with the fruit, the plant thereof is eaſily propagated by trunk roots; the white poppy being an annual plant is highly prolific, commonly bearing about four mature heads, in each of which are at leaſt ten partitions, on both ſides whereof the ſeeds grow, and on one fourth part of one ſide, about a hundred ſeeds, that is eight hundred on one partition, which multiplied by ten makes eight thouſand, and this multiplied again by four, the number of heads, gives thirty-two thouſand ſeeds, the yearly product of that plant.

So alſo in typha major, the ſeeds being blown off and ſown with great hazard, are prodigiouſly numerous, they ſtand altogether upon the ſpike, and make a cylinder at leaſt ſix inches long, and near five eighths of an inch in diameter. Nine of theſe ſeeds ſet cloſe together upon a right line make but the eighth of an inch, ſo that ſeventy-two make a line of an inch in length; but becauſe upon the ſpike, the hairs belonging to the ſeed come between them, we will abate ten, and count but ſixty-two; to which if three fourths be added (abating the fraction, viz. 46.) makes a hundred and eight, for the circumference of the cylinder, which being ſix inches long, there are ſix times ſixty-two for a line the length of the cylinder, which is three hundred ſeventy-two; which number being multiplied by a hundred and eight, produceth forty thouſand one hundred and ſeventy-ſix, the number of ſeeds that ſtand upon one ſtalk: therefore upon three ſtalks which one plant commonly bears, there are in one year a hundred and twenty thouſand five hundred twenty-eight ſeeds.

As ſoon as the ſeed is ripe, nature taketh ſeveral methods for its being duly ſown, not only in opening the uterus, but alſo in the make of the ſeed itſelf; for firſt the ſeeds of many plants which effect a peculiar ſoil, as arum, poppy, &c. are heavy and ſmall enough without further care to fall directly down into the earth, and ſo to grow in the ſame place where they had their own birth. But if the ſeeds are ſo large and light as to be expoſed to the wind, they are often furniſhed with one or more hooks, to prevent their wandering too far from their proper place, till by the fall of leaves or otherwiſe, they are ſafely lodged.

The ſeeds of avens have one ſingle hook, thoſe of agrimony and gooſe-graſs many, both the former loving a warm bank, and the laſt a hedge for its ſupport; on the contrary, divers ſeeds are furniſhed with wings or feathers, partly with the help of the wind to carry them when ripe from off the plant, as thoſe of aſh, maple, orach, &c. leaſt ſtaying thereon too long, they ſhould either be corrupted, or miſs their ſeaſon, and partly to enable them to make their flight more or leſs abroad; that by falling together, they may not come up too thick, and if one ſhould eſcape a good ſoil or bed, another may light thereon. The kernels of pine have wings, not unlike thoſe of ſome inſects, but very ſhort; in reſpect of the weight of the ſeed, they do not fly into the air, but only flutter about upon the ground; thoſe of typha dandelion, and moſt of the papous kind, with many more, have very long and numerous feathers, by which they are wafted every where, and to any convenient diſtance.

Some ſeeds are ſcatter'd, not by flying abroad, but by being ſpurted away as wood-ſorrel, fig. 437. which is effected by a white, thick and ſtrong cover of tendons of a ſpringy nature, in which the ſeed within its caſe is incloſed. This cover, as ſoon as it begins to dry, burſts open in an inſtant, on one ſide, and is violently turned inſide out, and ſo ſmartly throws off the ſeed.

The ſeeds of harts-tongue, fig. 439. and all that tribe, are flung or ſhot away by a curious contrivance in the ſeed-caſe; as in codded arſmart, or other like plants, only there the ſpring moves and curls up inwards, but here it moves outwards; every ſeed caſe ſtands upon a little pedicle, a a a, fig. 439. being of a ſilver colour, and of a ſpherical figure; it is girded about with a ſtrong tendon or ſpring a, (whoſe ſurface reſembles a fine ſcrew, of a golden colour, which breaks the caſe, immediately upon its becoming elaſtic enough) into two hemiſpherical cups, as at b c, and by that means fling off the ſeeds. Theſe caſes grow in furrows, d e, d e, d e, on the back of the leaf, as at fig. 438. in one of which of an inch long, are more than three hundred of the above-mentioned caſes; and allowing ten ſeeds to every caſe, makes three thouſand ſeeds; which multiplied by the number of furrows in one leaf, with allowance of the leſſer furrows, and that ſum by the number of leaves commonly growing upon one root, amounts to above a million of ſeeds,[a] the annual product of this plant. The ſeed is of a tawny colour, flat and ſomewhat oval; of theſe ten thouſand are not ſo big as a white pepper corn. Fig. 439. repreſents a few of the ſeed-caſes magnified; they were cut out of the furrow at f, in the leaf repreſented by fig. 438.

Divers notable means of ſemination are obſerved by other authors. Mr. Ray tell us, that a quantity of fern ſeed, laid in a lump, on a paper, the ſeminal veſiculæ are heard to crackle, burſt, and, by the microſcope, the ſeeds are ſeen to be projected to a conſiderable diſtance from each other.

Dr. Sloane obſerves, that the gentianella flore cæruleo, or ſpirit leaf, requiring wet weather to be ſown in, as ſoon as the leaſt drop of rain touches the end of the ſeed veſſels, with a ſmart noiſe, and a ſudden leap, it opens itſelf, and with a ſpring ſcatters the ſeed.

Other plants ſow their ſeeds by inviting birds by their agreeable taſte and ſmell, to feed on them, ſwallow them, and carry them about; thereby alſo fertilizing them, by paſſing through their bodies. In ſuch manner are nutmegs and mizzletoe ſown and propagated.

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[a] Grew. Ana. Plant. p. 119

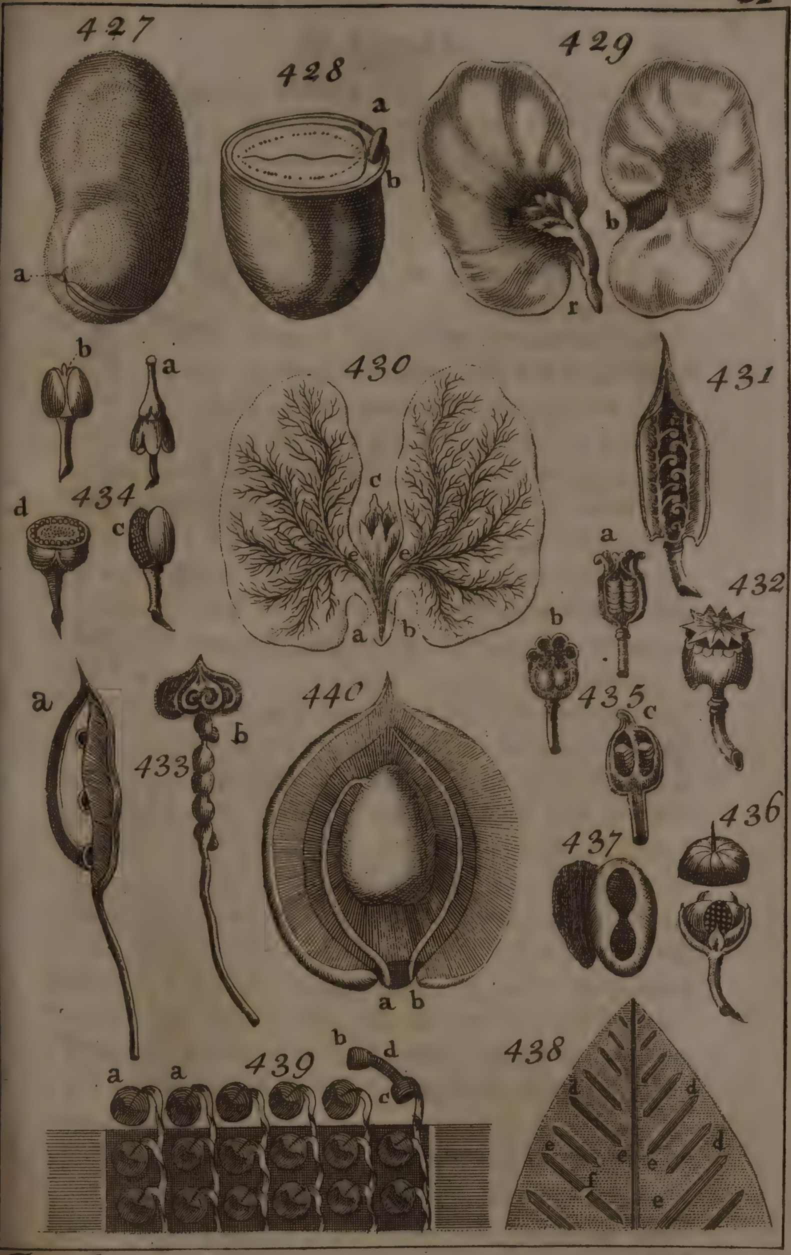
Of the cover of the ſeeds.

THE next ſtep which nature takes, relates chiefly to the growth of the ſeed, when ſown, and for this purpoſe the outer covers are ſomewhere furniſhed with apertures, ſufficient for the reception of alimental moiſture, to be received from the ground, and for the ſhooting forth of the young root into it; as in the ſeed of a gourd at the bottom, in a bean on the ſide, and in a cheſnut at the top, in which place the young plant always lies, and puts forth in the ſaid ſeveral ſeeds. The ſeed of palmi chriſti falls to the ground, not only in the uſual covers, but alſo in the ſaid caſe.

If the cover of the ſeed be ſtony, and very hard, it is divided into ſeveral pieces, whereby they eaſily cleave aſunder: the ſhell of a hazel nut, divides on the edge, and the cleft begins at the point, where the root ſtands and ſhoots forth; the ſhells of ſome walnuts cleave into four parts, and the ſtone of bellerick myrobalan into five: the covers and huſks of ſome ſorts of grain, as millet, are folded over each other, the better to give way to their tender ſprouts.

The covers of all, or at leaſt the far greater number of ſeeds, are three, and ſometimes four, even thoſe of ſtoned fruits have three, beſides the ſtone; in goſſipium, there are two under that lin'd with cotton. The ſeeds of cucumbers, goat's beard, broom, ſcabious, lattice, &c. although ſo ſmall, have plainly three coats; in ſome of theſe, and in many more, only two are diſtinctly viſible, except in the ſtate of generation. In the upper coat the ſeed-veſſels are diſſeminated; the ſecond is at firſt a mere pulp, which afterwards ſhrinks up, and ſticks cloſe to the upper. The third or inmoſt more denſe; and if it be thin, for the moſt

part



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part tranſparent; whereby the ſeed ſeems to be ſometimes naked while it lies therein, as in almonds, cucumbers, &c.

In meliſſa, and ſome other ſeeds, it comes finely off, on being ſoaked in warm water.

Of the fœtus, or true ſeed.

AMONG ſeeds of the thinner covers are thoſe of all ſorts of corn and graſs, different from that of moſt other ſeeds. The main body being of one entire piece, doubled in the form of a pair of lips. In the ſeeds of dates, and ſome other like plants, that which is generally called the ſtone, ſeems indeed to be the main body of the ſeed, doubled or folded up in the ſame manner as corn, to which that part which becomes the plant is annexed. In corn it is placed in the bottom of the main body, but here is a ſmall round cavity in the middle of the back.

For the moſt part the main body is divided into two lobes, plainly to be diſtinguiſhed in moſt kernels, and other large ſeeds, and not difficult in many leſſer ones, as in viola-lunaris, ſcabious, doves-feet, &c. if ſlipped out of their covers before they are full ripe; in hounds tongue they are of a circular figure; in cucumbers, oblong, with ſome viſible branches of the ſeminal root, &c.

In the foregoing ſeeds, the lobes lie flat one againſt another, but in garden raddiſh they are folded up, ſo as to receive the radicle into their boſom. In holy-oak the lobes are plaited over each other. In cotton ſeed they are very broad and thin, and their folds curious and very numerous.

Many of the ſeeds, with bulky covers, are not divided into two lobes, being in a manner of one piece, as all the bulbous kind: in flag it is above twenty times bigger than the ſeed within it, and conſiſts of bladders radiated towards the ſeat of the ſeed, and theſe diſpoſed in parallel lines running lengthwiſe.

But the greateſt number of ſeeds with bulky covers, are divided into two lobes. In the purging nut of angola, if the ſhell be taken off, the upper covers, (dried and ſhrunk up) ſeem to be but one: in theſe the ſpermatic veſſels are branched, and under them the thick and inmoſt cover; which being cut down the middle thereof, ſhews the true ſeed, conſiſting of two veined leaves, as white as milk, joined together with the ſtem or radicle at their baſe, and ſunk into a hollow made in the cover. The ſame is alſo obſervable in the Barbadoe nuts, ricinus, Americanus, and ſome other Indian fruits.

In the foregoing fruits, the bulky is very ſoft, but in nux vomica officinarum, it is nearly as hard as a date ſtone; in this, and the foregoing, the ſeeds are large, but in others are ſo ſmall, that they are ſcarce diſcernable without a microſcope, as in ſtaphiſagria. The thick or inmoſt cover is conical towards the baſe, at whoſe point is a little cavity where the ſeed is lodged; the root thereof pointed, and lobes rounded at the top. In peony the ſame cover is ſoft, white, and of an oval figure, the part uſed for medicine is thought to be the ſeed itſelf, but is near two hundred times bigger than the true ſeed; which lies in a little cavity near the bottom of the cover, with a blunt root, and two pointed lobes.

In coffee-berries, the ſeed lies in the inner cover, near the top; the back of the lobes are veined like two minute leaves, and joined to a long root.

The ſeed of ſtramonium is incloſed in a bulky cover, which being ſoaked in water, and carefully cut about the edges with a ſharp razor or penknife, its ſeed may be taken out entire, and examined by the microſcope.

Of the buds of ſeeds.

THE ſtalk of the plant riſes up from between the lobes, which may always be ſeen, in ſome by the naked eye, and in others by the microſcope; in many plants nature ſees fit only to lay the foundation thereof in a round node, as in viola luniaria, &c.

But in moſt ſeeds is formed a true bud, conſiſting of perfect leaves, in ſome two, others four, &c. In bayberry only two, very ſmall, but thick, and finely veined; in the ſeed of carduus benedictus, they are alſo two, pointed at top, and ſituate a little diſtance from each other, for the two next to riſe up between them.

In ſome herbs, although the bud conſiſts but of two perfect leaves, yet they are very conſpicuous, not only in the larger ſeeds, as phæſcolus, or French beans, but in ſmall ones too, if examined by the microſcope, as in the ſeed of hemp. A B, fig. 441. in which the two leaves are plaited, and ſet edge to edge, c ſhews the other part of the ſeed which was ſeparated to lay the bud fair to view. In the ſeed of ſenæ, the bud hath four leaves: in the ſeed-bud of an almond C, D, fig. 442. there are ſix or eight, and ſometimes more diſtinct leaves viſible, if by a dextrous ſeparation of the outer, the innermoſt are laid open, they are folded inward one over the other, as appears at D, which repreſents them open, and at C the ſame ſeed-bud is ſeen ſhut.

The lobes of the ſeed, and ſo likewiſe the ſtalk and bud, conſiſt of a ſkin, parenchyma and branched veſſels, as before deſcribed; all which are apparent to an eye armed with a microſcope.

The firſt ſkin, as in French-beans, may be eaſily ſeparated from the parenchyma, eſpecially if the bean be ſoaked in water for ſome days, it will ſlip eaſily off, and will be found to conſiſt of bladders, ſmaller than thoſe of the parenchyma, and intermixed with a kind of lignous fibres which give a toughneſs to the ſkin. The branched veſſels run through the parenchyma, and compoſe the ſeminal root in the lobes, being no where extended to the circumference of the lobes, but are all inoſculated together at a conſiderable diſtance from it; all meeting therein in one ſolid nerve, but in the ſtalk are dilated into an hollow trunk, filled with a pith compoſed of bladders, which in the ſtalks of French beans is very conſpicuous; they conſiſt of ſap and air veſſels as the other parts of a plant, not running collateral, the latter being ſheathed in the former, and are plainly viſible in the microſcope.

Of the generation of the ſeed.

AS a garden bean was choſe to ſhew the manner of the ſeeds vegetation, ſo an apricock is very fit to obſerve and repreſent the method nature takes in its generation.

A proper uterus is firſt prepared, both to keep the membranes of the fœtus warm and ſucculent, and to preſerve and ſecure it afterwards till it takes root in the ground. For this purpoſe both the pulp and ſtone of the fruit are neceſſary; but firſt the ſtone, the pulp being only neceſſary to form the ſtone, the petrifying of that parenchyma which is the ground of the ſtone, being effected by the ſinking of the tartar [x] thereinto; for

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[x] Grew. An. of Plants, p. 209.

It is evident on cutting a young apricock, and then with a ſharp razor ſhaving off a thin ſlice, and viewing it through the microſcope, that at firſt the ground of the ſtone is a diſtinct and ſoft parenchyma, compoſed of bladders, as the pulp itſelf is, which bladders, as they harden into a ſtone, fill up and diſappear.

This parenchyma takes its riſe from the pith, as the pulp does from the bark, and compoſes the greateſt part of the ſtone; its inſide is lined all over with a thin ſkin, covering the ſeed branch on its firſt entrance into the hollow of the ſtone; which ſkin is alſo compoſed of exquiſitely ſmall bladders, by which means it ſoon becomes a very hard and dry body.

The ſtone being made hard and dry, could never be ſufficiently ſoftened (to give paſſage for the vegetation of the ſeed) by lying under ground, did it not eaſily cleave in two; for which purpoſe the ſkin of the fruit is immediately concerned; for in a tranſverſe ſlice of a young apricock, if it be cut with a ſharp knife, this ſkin may be ſeen (when applied to the microſcope) fairly doubled inwards from the two lips a b, a b, of the fruit, fig. 443 and 444. and from thence continued through the pulp and ſtone itſelf into the hollow thereof, where it meets and is united with the lining before-mentioned; and as it conduces towards the drying of the ſtone, ſo alſo it renders it cleaveable in that part where it runs through it.

Nature having thus provided a convenient uterus, her next care is about the membranes of the fœtus, theſe are three apparently diſtinct, and in many reſpects different from each other.

The firſt of theſe, fig. 443. repreſents a tranſverſe ſlice of a young apricock near the lower end, ſhewing the duplicature of the ſkin half way through the ſtone. Fig. 444. a tranſverſe ſlice cut through the upper end, ſhewing the duplicature of the ſkin quite through the ſtone; and at e f, fig 446. is ſhewn the branches which run through the ſtone to the flower and ſeed, in a well grown apricock cut lengthwiſe.

The outermoſt of theſe membranes takes its riſe from the parenchyma, and ſurrounds the ſeed branch, and upon its entrance into the hollow of the ſtone is expanded into two bladders, one within the other; whereof one becomes the lining of the ſtone, the other the outer membrane, and is beſt ſeen on cutting a young apricock when it is about half an inch long through the middle, or from the ſeat of the flower to the ſtalk, between the two lips a b, fig. 443. At this age the outer membrane hath a full and firm body, and is compoſed of bladders, as may be plainly ſeen on its application to the microſcope.

The veſſels contained in the ſeed branch, are diſtributed throughout this membrane, beginning a little below its ſmaller end, and running round both ways, meet in the middle of the greater, where they are all inoſculated and form a kind of umbelical node, as at a, fig. 445. from whence they ſtrike deeper into it till they arrive at the middle membrane, where they become inviſible; theſe veſſels convey the ſap to the middle membrane, whoſe bladders are more angular and amplified towards the center, being at leaſt two hundred [z] times bigger than thoſe of the outer membrane.

This middle membrane is ſo called from the ſtate and condition it hath upon the augmentation of the ſeed, at which time it obtains the name of an involucrum [a], but originally is every where entire without any hollow, filling up the cavity of the outer membrane like a ſoft and delicate pulp. After a ſhort time a ſmall channel appears therein, running from the bottom to the top; at firſt no wider than to receive a human hair, and then only viſible in a tranſverſe ſlice, and that not without a microſcope; but when grown a little wider, may be ſeen if the membrane be carefully cut lengthwiſe, at which time it is dilated into two oval cavities, e f, fig. 446. one at each end, into which a moſt pure lympha continually owzeth, and is therein reſerved for the nouriſhment of the ſeed, and alſo paſſes freely from one to the other.

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[z] Grew, An. Plan. p. 210.

[a] Ibid.

A few days after this, the inmoſt membrane begins to appear like a ſoft bud growing out of the upper cavity, being joined to its lower end by a ſhort and tender ſtalk; from whence it is produced into a conical oval figure, anſwerable to that marked g in the cavity, fig. 447. This membrane, though ſoft and full of ſap, is compoſed of bladders, three hundred times ſmaller than thoſe of the middlemoſt, by which means the ſeed is ſo well guarded, as not to be ſupplied with any other part of the lympha but the pureſt, and that only but by ſlow degrees.

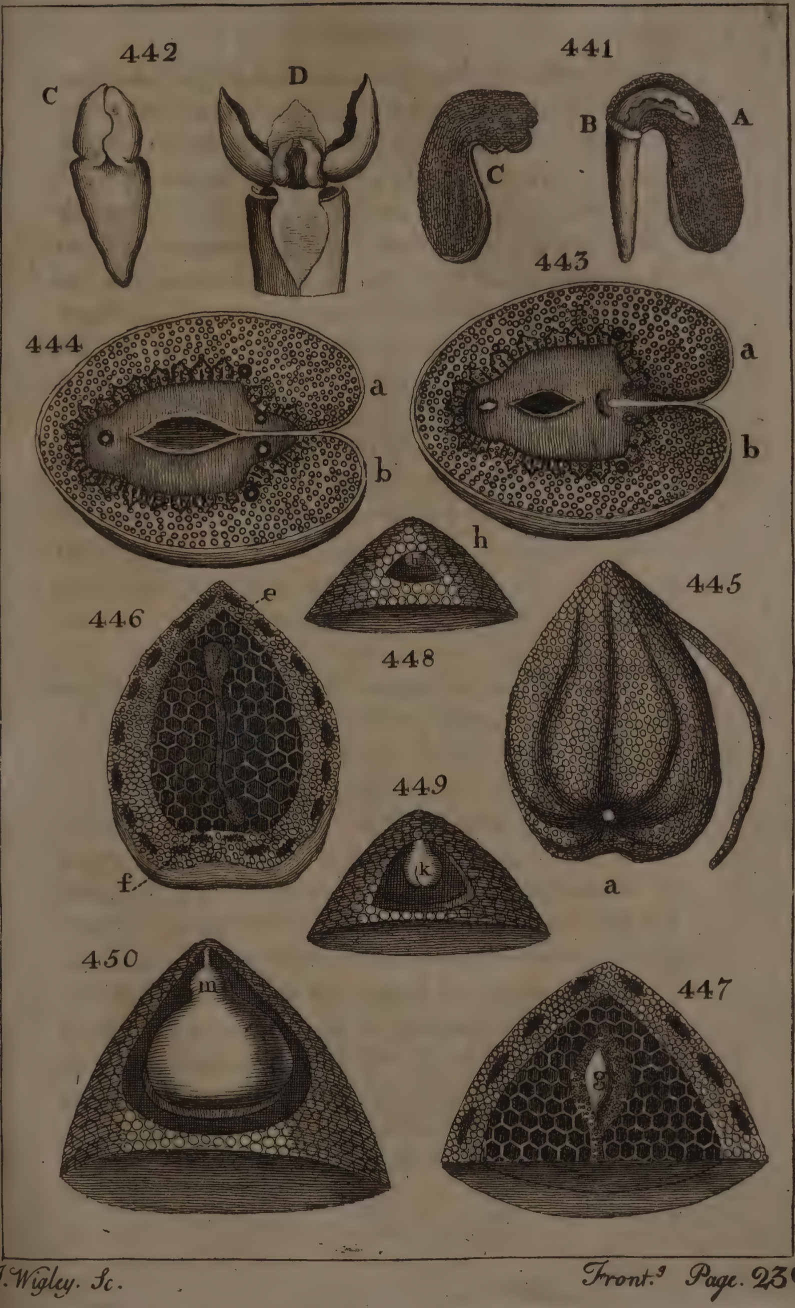
If with a ſteady hand this membrane be pulled very gently upwards, it will draw a ſmall tranſparent ſtring after it to the bottom of the middle membrane: this ſaid ſtring, though for the greater part parenchymous, is nevertheleſs ſtrengthened with ſome lignous fibres, which ſeem to be a portion of thoſe that are inoſculated at the bottom of the outer membrane, and thence produced through the middlemoſt under the channel which joins the two oval cavities, till at laſt they break forth into the upper cavity, where they form this inner membrane, which is originally as entire as the middlemoſt; but as it increaſes, becomes a little hollow near the cone, and the aforeſaid lignous fibres fetching their compaſs from the baſe, ſhoot forth into the cone, and make a very ſmall node therein, for the firſt eſſay towards the generation of the ſeed, as at h, fig. 448. which are ſpun out to the utmoſt degree of fineneſs for that purpoſe. In this figure the inmoſt cover is laid open to ſhew the ſeed itſelf.

When this node is grown to about the ſize of the fifth part of a cheeſe-mite, it begins to be divided by a little indenture towards the top, as at k, fig. 449. which gradually grows deeper till the node is diſtinguiſhed into lobes or thick leaves; and as theſe increaſe, their baſe is contracted into the radicle, or that part of the ſeed which becomes the root; at this time the ſeed is ſo extremely ſmall, that the lobes cannot be ſeparated; but it is probable, that as ſoon as the radicle is finiſhed, the next ſtep is the puſhing forth another node between the lobes, in order to the formation of the bud, and ſo the perfection of the ſeed.

This being done, or doing, the ſtalk of the ſeed is more and more contracted at bottom, and hangs at the inner membrane only by an extremely ſmall and ſhort ligament m, fig. 450. which at laſt breaks; and then the ſeed, as fruits when ripe, falls off and lies looſe in the inner membrane, which gradually ſhrinks up and becomes more hollow to make more room for the farther growth of the ſeed.

In Malpighi's life was a debate between him and Seignior Triumphetti, provoſt of the phyſick garden at Rome, whether the whole plant be actually contained in the ſeed? the affirmative is maintained by Malpighi with cogent arguments; among which this is one, that in a kidney bean, 'ere ſown, the eye, aſſiſted with a microſcope, eaſily diſcovers leaves, a bud, and even the knots or implantation of the leaves on the ſtem. The ſtem itſelf is very conſpicuous, and plainly conſiſts of woody fibres, and a ſeries of little utricles. Whereas Seignior Triumphetti had objected, that by poverty, tranſplantation, &c. ſeveral plants degenerate into others, parti-

Pl. 52



J. Wigley. Sc.

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particularly wheat into tares, and tares again into wheat. In anſwer to this, which is one of the ſtrongeſt objections againſt that opinion, Malphigi replies, that he is not fully ſatisfied as to the truth of the objection; for that both himſelf and his friends making the experiment, no metamorphoſis of the wheat ſucceeded: but granting the metamorphoſis, it is the ſoil, or the air, or the culture that is in fault. Now, therefore, from a morbid, and monſtrous condition of nature, there is no inferring her genuine and permanent ſtate.

That experiment related in the following ſection, of the orange kernel, which Mr. Leeuwenhoek made to germinate in his pocket, is a plain demonſtration, that the plant, and all that belongs to it, was actually in the ſeed itſelf.

Of the ſeed of oranges.

THE proceſs of nature in the vegetation of plants, is very accurately deliver'd by Mr. Leeuwenhoek, to the effect following, by an orange kernel which he made to germinate in his pocket, viz.

The kernels of oranges being diveſted of their outer membrane, will appear as fig. 451. on one ſide of which lies a ſtring a, which cauſes a little protuberance in the firſt ſkin; from this ſtring, not only the ſeed, but alſo the plant within it, receive their increaſe and nouriſhment, and to which through the ſecond membrane, it extends its ſmall veſſels to the ſeat of the plant. Mr. Leeuwenhoek was of opinion, that this ſtring does actually comprehend in itſelf, as many diſtinct veſſels as are to be found in the orange-tree when arrived at its full maturity [b]. For, ſays he, if all theſe veſſels were not in the

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[b] Phil. Tranſ. No. 287.

young plant, whilſt it lies involved in the kernel's matrix, whence could they afterwards proceed? Fig. 452. repreſents part of the ſame ſtring, cut a-croſs, and greatly magnified, which at K L M N, has abundance of exceeding ſmall veſſels, but very difficult to be perceived. About I H N M, they grow larger, and conſequently are more viſible. B, fig. 453. repreſents a ſeed diveſted of its membranes, which ſeemed to have but one plant within it, though often there are two, and ſometimes three diſtinct ſeeds with their plants contain'd under the membrane of an orange kernel; theſe ſeeds, with their incloſed plants, are eaſily divided into two lobes; which are framed by nature to nouriſh the tender plant within, till it is able to ſtand alone, and draw its ſubſiſtence from the earth about it; having ſplit the ſeed into two parts, they are repreſented by C and D, fig. 453. in the firſt, is part of the plant, which would have become a tree, and is no bigger than a grain of ſand to the naked eye. The counterpart of the ſaid kernel is repreſented at D, with the concave, in which part of the plant lay. Fig. 454. repreſents the laſt mention'd plant, as it appear'd in the microſcope, whereof Q L M is partly that which nature intends for the body and root of the tree; M N O P Q the leaves with which the young plant is already provided, N O P that part of the leaves which is ſomewhat protuberant, by reaſon of the ſmall incloſed leaves M N, and P Q ſhew the two ſides of the plant torn off from the kernel, to which it was united, and from which it received its nouriſhment. Fig. 455. S T V, ſhews the ſame plant a little turned about before the microſcope, in order to repreſent the two largeſt leaves, between which, according to all appearance, a great many ſmall ones are ſhut up. If the leaves be cut a-croſs, ſome of the included ones may ſometimes be diſcerned, and on cutting that part of the plant which is to be the body and root of the tree, that which was deſigned for the pith, and even the wood itſelf may be diſcover'd.

Fig. 456. ſhews the root when the plant vegetates, T V and W X the two halves of the kernel, and Y that part which is to become the body of the tree.

Fig. 457. repreſents the young plant of twelve days growth, whereof A C D ſhews the root, and F G that part which is to be the tree, D E the ſeed or kernel, which being ſurrounded with its membrane, which was taken off the better to expoſe thoſe parts to view, that ſerve for the nouriſhment not only of the root, but of the upper parts of the plant likewiſe, as alſo the ſhort ſtring D. Thus we may ſee how ſmall a particle, that is no bigger than a grain of ſand, [c] as the plant was at firſt, is increaſed in bulk! and all this is brought about by heat and moiſture, it being rais'd to this degree of perfection in ſome ſand firſt moiſtened, and then incloſed together with the ſeed, in a glaſs tube, wore all day in the pocket, cloſe to the body, and at night, placed within a large tin bottle, filled with hot water, which is a plain demonſtration that the plant, and all that belonged to it, was actually in the ſeed; that is to ſay, not only the young plant, its body, root, and fruit, but even its ſeed alſo, to perpetuate the ſpecies; as hath been before obſerved.

Mr. Leeuwenhoek comparing the animalcula in ſemine maſculino, and theſe plants, computes them to be one million times ſmaller than a plant in an orange-kernel; and though we cannot make our obſervations of the growth and increaſe of the ſaid animalcula from time to time in their mother's matrix; yet we may certainly conclude, that the laws which the wiſe creator of all things hath preſcribed to himſelf, in the production both of animate and inanimate creatures, are homogeneous and uniform; and that as the earth is the common matrix of plants, ſo is the fallopian tube in moſt of thoſe animals that are formed ex ſemine maſculino; for as theſe receive their nouriſhment, and increaſe by a ſtring, till they are brought into the world; ſo are all ſeeds (at leaſt as far as we know) ſupported and nouriſhed by a like ſtring; and the ſeeds thrown into the ground, do again, by the ſame ſtring, whereby they received their increaſe, convey nouriſhment to the ſeed or kernel.

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[c] Phil. Tranſ. No. 287.

Of the ſeeds of venus looking-glaſs, or corn violets.

FIG 458. repreſents one of the ſeeds of corn-violets; the ſeed is very ſmall, black, and ſhining, and to the naked eye looks almoſt like a very ſmall flea, but through the microſcope appears to be covered with a tough, thick, and bright, reflecting ſkin, very irregularly ſhrunk, and pitted, that it is almoſt impoſſible to find out two of them wrinkled alike, ſo great a variety there is even in this little ſeed.

Of the ſeeds of thyme.

THESE little ſeeds, although they differ ſomewhat in figure and bulk, yet when looked at through the microſcope, all of them exactly reſemble a dried lemon, one of which is repreſented at fig. 459. ſome of them are a little rounder, and of the ſhape of an orange. They have each of them a conſpicuous part, by which they are joined to their little ſtalks; they are a little creaſed or wrinkled, as is expreſſed in the figure.

Of

Of the ſeeds of poppy.

POppy ſeeds, one of which is repreſented in fig. 460. deſerve to be taken notice of among the other microſcopic ſeeds of vegetables; both for their ſmallneſs, multiplicity, and prettineſs, and alſo for their admirable ſoporific quality, although they grow in a very large caſe, yet are they ſo ſmall, as not to exceed the bulk of a very ſmall nitt, being not above one thirty-ſecond part of an inch in diameter; whereas the ſeed caſe oftentimes exceeds two inches, and is therefore capable of containing near two hundred thouſand of them. They are of a browniſh coloured red, curiouſly honey-combed all over with a pretty variety of net-work, or a ſmall kind of emboſſment of very orderly raiſed ridges.

Of purſlane ſeed, &c.

THE ſeeds of purſlane ſeems of very notable ſhapes, and appear through the microſcope like porcelane ſhells, as at fig. 461. It is coyled round in the manner of a ſpiral; at the greater end, which repreſents the mouth or orifice of the ſhell, is a white, ſkinny, tranſparent ſubſtance B, which ſeems to be the place where the ſtem was joined. Its whole ſurface is covered with little prominencies, orderly ranged in ſpiral rows; one of theſe being cut aſunder with a ſharp penknife, diſcovered the ſhell to be of a browniſh red, but ſomewhat tranſparent, and manifeſted the inſide to be filled with a whitiſh green pulp, the bed wherein the ſeminal principle lies inveloped.

Fig. 465. repreſents the ſeed of ben; it is ſomething like a kidney, but hath its circumference raiſed up into double ridges, towards which ſeveral ſmall ridges do in ſome ſort radiate from one center.

Fig. 464. repreſents the ſeed of chickweed, this alſo is partly like a kidney, and partly like a retort, being rough caſt with ſmall pieces, as if they were inſects with little feet.

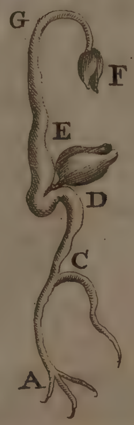
Fig. 463. repreſents the ſeed of bellis tanaceti folio. It hath two triangular ſides, and the third conical; the two firſt have ſeveral ridges running to the baſe, the head triangular with one ſide convex, the other two ſtreight, with a little pinnacle in the center.

Fig. 462. repreſents ths ſeed of wartworth, or ſun ſpurge, it is of a very complex figure, its belly conſiſting of two planiconic ſides, and back ſphericonic. The baſe and head are both flat, in the middle of the former is a peg, by which the ſeed is faſtened, and of the latter a pointed knob. The belly-ſides is hollowed, ſo as to make a flat rim of equal breadth; and the hollows filled up with bladders, like thoſe of the parenchymous parts of a plant.

There are multitudes of other ſeeds, which imitate the forms of divers ſorts of ſhells; as ſeed of ſcurvy-graſs, a kind of purcelane ſhell; others repreſent ſeveral ſorts of larger fruits; ſweet and pot marjoram repreſent olives, carrot-ſeeds are like a cleft of a cocoa nut huſk. Others are like artificial things, as ſuccory ſeeds are like a quiver of arrows, the ſeeds of aramanthus are ſomewhat like an eye, the ſkin of the black and ſhrivelled ſeeds of onion, are all over knobbed like a ſeal ſkin, and ſorrel has a black ſhining three-ſquare ſeed. It is almoſt endleſs to reckon up the ſeveral ſhapes of ſeeds, they being ſo many and ſo various in their forms. I ſhall therefore leave them

Pl. 53

457



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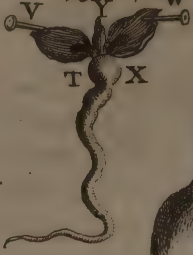

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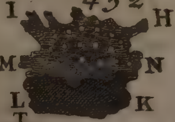

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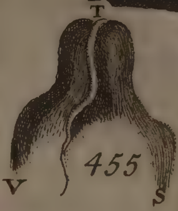

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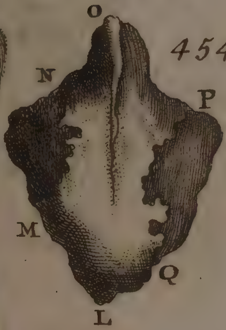

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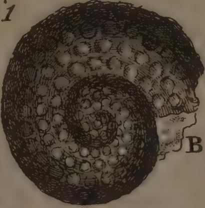

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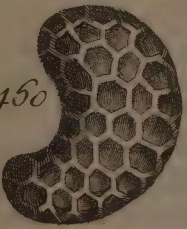

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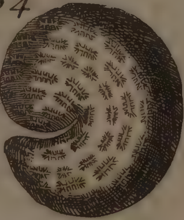

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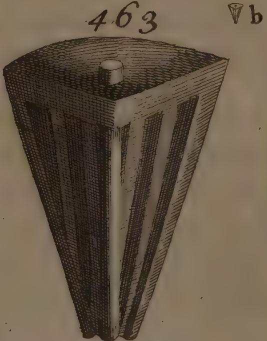

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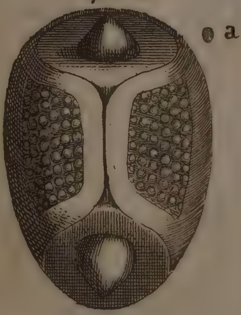

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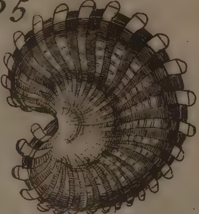

Front.^{g} Pag. 236 Bowles ſc.

them to the further examination of the curious obſerver.

The ſeed or powder of the fungus purverulentus, or puff-ball, when cruſhed, appears like ſmoak to the naked eye, but when examined by one of the greateſt magnifiers, is found to be infinite numbers of little orange coloured globules, ſomewhat tranſparent; in another ſort the globules are of a darker colour, each of them having a little ſtalk or tail, which are evidently ſo many minute puff-balls [d], furniſhed with ſtalks, to penetrate eaſily into the ground, and the miſchiefs they do the eyes, is probably owing to the ſharpneſs of theſe ſtalks [e], which prick and wound that tender organ.

Of the roots of plants.

THE root is that part of a plant which immediately imbibes the juices of the earth, and tranſmits them to the other parts for nutrition. It conſiſts of woody fibres, covered with bark, more or leſs thick, and ariſes from a little point in the ſeed called the radicle.

We learn by the aſſiſtance of the microſcope, that plants conſiſt of different parts, veſſels, &c. each of which is ſuppoſed to be the vehicle of a different humour, or juice, ſecreted from the maſs of ſap, which is conſidered as the common fund of them all.

I muſt not here omit a curious phenomenon in the natural hiſtory of plants, and that is, when the radicle in ſowing happens to light loweſt, it is no wonder the root ſhould ſpread itſelf under ground, and the ſtem of the plant riſe up perpendicularly: but when the radicle falls uppermoſt, by what means it is that it changes its poſition,

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[d] Phil. Tranſ. No. 284.

[e] Derham's Phyſ. Theo. p. 418.

tion, to favour the aſcent of the ſtem, is one of the wonders of vegetation.

M. Dodart firſt obſerved this perpendicularity of plants, and publiſhed it in an expreſs eſſay of the affectation of perpendicularity, obſervable in the ſtems or ſtalks of plants, &c.

The matter of fact is, that though almoſt all plants riſe a little crooked; yet the ſtems ſhoot up perpendicularly, and the roots ſink down perpendicularly; even ſuch as by the declivity of the ſoil come out inclined, or are diverted out of the perpendicular by any violent means, again redreſs or ſtrengthen themſelves, and recover their perpendicularity, by making a ſecond or contrary bend, or elbow, without rectifying the firſt.

A common eye looks on this affectation without any ſurprize; but a man, who knows what a plant is, and how formed, finds it a ſubject of aſtoniſhment.

It has been before ſhewn, that each ſeed contains a little plant, already formed, needing nothing but to be unfolded; the little plant has its little root and pulp, which is generally ſeparable into two lobes, and is the foundation of the firſt food the plantule draws by its root, when it begins to germinate.

If a ſeed in the earth be ſo diſpoſed, as that the root of the little plant be turned downwards, and ſtem upwards, and even perpendicularly upwards; it is eaſy to conceive, that the little plant coming to unfold itſelf, its ſtalk and root need only follow the direction they have to grow perpendicularly. But,

It is very well known, the ſeeds of all plants, whether ſown of themſelves, or by the help of man, fall into the ground at random; and among an infinite number of ſituations, with reſpect to the ſtalk of their plant, the perpendicular direction upwards is but one.

It is therefore neceſſary that the ſtalk redreſs or rectify itſelf in all the other ſituations, in order to find its way out of the ground: but what force is it that effects this change, which is certainly a violent action? Is it, that the ſtalk finding a leſs load of earth above it, goes naturally that way where it finds the leaſt obſtacle? were it ſo, the little root when it happens to be uppermoſt, muſt for the ſame reaſon follow the ſame direction, and mount on high.

Therefore M. Dodart ſuppoſes the fibres of the ſtalks are of ſuch a nature, as to contract and ſhorten by the ſun's heat, and lengthen out by the moiſture of the earth; and on the contrary, that the fibres of the roots contract by the moiſture of the earth, and lengthen by the heat of the ſun.

Then when the root of the plantule is uppermoſt, the fibres which compoſe one of the branches of the root, are not equally expoſed to the moiſture of the earth; the lower part is more expoſed to the upper, which muſt therefore contract the moſt; this contraction is again promoted by the lengthening of the upper, whereon the ſun acts with the greateſt force; conſequently this branch of the root muſt recoil towards the earth, and inſinuating through the pores thereof, get under the bulb, &c.

By inverting this reaſoning, it will appear, how the ſtalk comes to get uppermoſt.

In a word, we may imagine, that the earth attracts the root to itſelf, and that the ſun contributes to its deſcent; and, on the contrary, that the ſun attracts the ſtem, and the earth in ſome meaſure ſends it towards the ſame. Again,

M. de la Hire imagines, that the root draws a coarſer and heavier juice, and the ſtem and its branches a more volatile one; which difference of juices, ſuppoſes larger pores in the roots than in the ſtalks; therefore in the plantule we may conceive a point of ſeparation; ſuch, that all one ſide of the root ſhall be unfolded by the groſſer juices, and all the other ſide by the more ſubtile ones.

If now the plantule be inverted when its parts begin to unfold, the juices which enter the root being coarſeſt, when they have enlarged the pores to admit juices of a determinate weight, thoſe juices preſſing the root more and more, will drive it downwards, and this the more as the root is more extended or enlarged; for the point of ſeparation, being conceived as the fix'd point of a lever, they will act by the longer arm. At the ſame time the volatile juices having penetrated the ſtalk, will tend to give a direction from below upwards, and by reaſon of the lever, will give it more and more every day till it be perfectly erect.

Mr. Aſtruc accounts for perpendicularity of the ſtems, and their redreſſing themſelves on theſe two principles.

Firſt, that the nutritious juice ariſes from the circumference of the plant, and terminates in the pith. Second, that fluids contain'd in tubes, either parallel or oblique to the horizon, gravitate on the lower part of the tubes, and not at all on the upper.

Whence it eaſily follows, that in a plant poſited either obliquely or parallel to the horizon, the nutritious juice will act more on the lower part of the canals than on the upper; and by this means inſinuate more into the canals communicating therewith, and be collected more copiouſly therein; thus the parts on the lower ſide will receive more accretion, and be more nouriſhed than thoſe on the upper; the couſequences whereof muſt be, that the extremity of the plant will be obliged to bend upwards.

The ſame principle brings the ſeed into its due ſituation at firſt; in a bean planted upſide down, the plume and radicle are eaſily perceived with the naked eye, to ſhoot at firſt directly for about an inch; but thenceforward they begin to bend, the one downwards, and the other upwards, as in the example of the orange ſeed, fig. 457; the like is ſeen in a heap of barley to be made malt, in a quantity of acorns laid to ſprout in a moiſt place, &c. each grain of barley in the firſt caſe, and each acorn in the ſecond, hath a different ſituation, and yet all the ſprouts tend directly upwards, and the roots downwards, and the curvity or bend they make, is greater or leſs as their ſituation approaches more or leſs to the direction wherein no curviture at all would be neceſſary. Now two ſuch oppoſite motions cannot ariſe without ſuppoſing ſome conſiderable difference between the two parts; the only one we know of, is, that the plume is fed by a juice, imported to it by tubes parallel to its ſides; whereas the radicle imbibes its nouriſhment at all the pores in its ſurface. As oft therefore as the plume is either parallel or inclined to the horizon, the nutritious juice, feeding the lower parts more than the upper, will determine its extremes to turn upwards, for the reaſon already aſſigned. On the contrary, when the radicle is in the like ſituation, the nutritious juice penetrating more copiouſly through the upper part than the under, there will be a greater accretion of the former than the latter; and conſequently the radicle will be bent downwards; and this mutual curvity of the plume and radicle muſt continue, till ſuch time as their ſides are nouriſhed alike, which cannot be till they are perpendicular [f].

Roots are generally diſtinguiſhed by their figures, ſome being entire, as liquorice; parted, as ſaint johnwort; ſome

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[f] Men. d. l. Acad. Roy. des Sciences, No. 1708.

parted at bottom, as moſt roots; others at top, as dandelion, &c. ſome parted and ramified, as comfrey; others having divers ſtrings iſſuing from one head, as crowfoot; ſome ſtrait as raddiſh, crooked as biſtort, ſmooth as bugloſs, ſtringy all round as columbine; ſome thick as rhubarb, ſlender as the vine, long as fennel, ſhort as turnep, &c. &c.

The motions of roots are ſometimes perpendicular, as parſnip, level as hops, ammi, cinquefoil, &c.

There is a kind of wreathing or twiſting in the veſſels of ſome when the bark is ſtripped off, in carduus, ſonchus, &c. in which may be ſometimes ſeen two or three circumvolutions.

But the moſt remarkable of all roots are ſuch as are annually renewed or repaired out of the trunk or ſtalk itſelf, as arum, rape-crowfoot, valerian, brownwort, bearsfoot, tanſy, lychnis, ſapier, primroſe, ammi, avens, wood-ſorrel, iris, and others; that is to ſay, the baſis of the ſtalk continually and by inſenſible degrees, deſcending below the ſurface of the earth, and hiding itſelf therein, is both in nature, place, and office, changed into a root. So in brownwort the baſis of the ſtalk ſinking down by degrees till it lies under ground, becomes the upper part of the root; and continuing ſtill to ſink, the next year becomes the lower part, and the next after that rots away,[g] a new addition being yearly made out of the ſtalk, as the older parts annually rot away.

In a diſſection of the root we ſhall firſt find the ſkin, next the cortical, which when thin is commonly called the bark; next within this are the woody fibres, which together with all its parts, are viſible in a circle; its pores being nothing near ſo numerous as that of the cortical, but in ſome more open than in others, as may be ſeen on cutting

[g] Grew. Anat. of Plant. p. 59.

cutting a very thin tranſverſe ſlice of the branch of a tree, and holding it againſt the light, or placing it before the microſcope. In currant and gooſeberry-trees it is leſs conſpicuous than in oak or plumbs, in damſins it is more, and in elder and vines more; the cortical body doth not only ſurround the wood, but is as it were wedged into it in many places, and is even inſerted therein as far as the pith, and appears in a tranſverſe ſection of a root-like lines drawn from the center to the circumference.

Fig. 466. repreſents a tranſverſe ſlice of the root of aſparagus, and fig. 467. exhibits a microſcopic picture of a piece thereof cut out at a b, in which A B ſhews the ſkin: A B C D the bark, or all that part analogous to it: C D E F the lymphæducts on the inner edge of the bark: E F G H the wood in which the black ſpots ſhew the air veſſels: G H I the pith.

Fig. 468. is a tranſverſe ſlice of the root of mallows. Fig. 469. repreſents a piece thereof, which was cut out at c d, as it appeared before the microſcope; in which A B C D ſhews the ſkin: C D E F the bark, or all that part of the root which anſwers to it, in which the round ſpots are the muciducts: E F G H the common lymphæducts: G H I K the pithy part of the root: I K L more lymphæducts, in both which the black holes are the air veſſels.

Fig. 470. repreſents a ſlice of a vine root cut tranſverſly, out of which at e f was cut a ſmall piece, which when placed before the microſcope appeared as repreſented by fig. 471. wherein A B ſhews the ſkin: A B C D the bark: L S parcels of ſap veſſels: L I parcels of wood in which the darker ſhaded circles great and ſmall are the air veſſels: E F parenchymous inſertions between the parcels of wood: G G others within them.

At fig. 472. is ſeen a tranſverſe ſlice of a horſe-raddiſh root, and at a b the place from whence a gore was cut, which is repreſented as it appeared in the microſcope by fig. 473. whereof A B is the ſkin: A B C D the bark: C D E F G H I the ſap veſſels in form of a glory: C D K L the wood in which the darker circles are the air veſſels: K L M N a ring of more ſap veſſels: M N O the pith.

Fig. 474. exhibits a tranſverſe ſection of bugloſe root, from which at c d was taken a ſmall piece, that when magnified appeared as fig. 475. in which A B is the ſkin: A B C D the bark: A B E F the bladders in the outer part of the bark; they are figured ſomewhat oblong, and are ranged in circles: E F C D the inner part of the bark in which the bladders are ranged in curved arches: C D G H a ring of ſap veſſels: I I a parenchymous inſertion, of which there are ſeveral in the whole ſection: L K K L the wood in which the dark ſpots are the air veſſels: K K M the pith.

Of the ſkin of roots.

THE outer parts of all roots is the ſkin, which in ſkerrits is white, yellow in dock, red in potatoes, brown in lovage, black in bugloſs, &c. their ſurface is ſometimes ſmooth, as in horſe-raddiſh, rough, as in ſcorzonera. The ſkins of the ſeveral ſhells of a tulip-root freſh taken up, appear to be perforated with a number of ſmall holes. This ſkin is very thin in parſnip, thicker in bugloſs, very thick in iris, opake in ſome as the thiſtle, and tranſparent in others, as the madder.

Every root hath two kinds of ſkin, one of the ſame age with the other parts, and the other ſucceeding in the place of the former; as in dandelion, the old ſkin ſeems to be that part which compoſed the cortical body the year before, which by the generation of a new ring next the wood, is now thruſt outward, and ſhrunk up into a ſkin as at A B; in an horſe-raddiſh root, fig. 473. or at A B in a bugloſs root, fig. 475. as far as the bladders in the former, and veſſels in the latter, are radicated; the cortical body ſeems to ſhrivel up into a new ſkin, as the old ones fall off, and probably the whole body of the perpendicular roots, except the woody fibre in the center, becomes the ſecond ſkin, as in aſparagus, fig. 467.

This ſkin is made up of two kinds of bodies, one parenchymous, generally compoſed of exceeding ſmall cells or bladders, which are plainly viſible, if viewed through a microſcope, and appear as in fig. 467. which repreſents a tranſverſe piece of the root of aſparagus, &c.

The other part of this ſkin is compoſed of tubular wood-veſſels, intermix'd with the bladders before-mention'd.

If a root be cut tranſverſly, and laid by for ſome time, all the parts where there are no veſſels will ſhrink below the ſurface of the cut end; but the veſſels will all retain the ſame length, at which time they may be examined by the microſcope.

Of the bark of roots.

THE bark is ſituate juſt within the ſkin, in ſome roots it is yellow, as in dock, red in biſtort, but in moſt white, in ſome it is very thin, and in others it makes the greateſt part of the root, the thinneſt and thickeſt being all analogous.

It is exceeding porous both in length and breadth, as appears from its ſhrinking up equally both ways, and dilating to its former ſize on being ſoaked in water. All this is apparent to the naked eye; but the microſcope confirms the truth thereof, by ſhewing that theſe pores are an infinite number of little cells or bladders, ſometimes running in ranks both the length and croſs-ways of the root, as at A B C D in bugloſs. Fig. 475. it may be ſeen both in a tranſverſe and upright ſection, and always beſt after the pieces ſo cut have lain by ſome time to dry.

This parenchymous part is of an uniform texture in many roots, and diverſified in as many others; the bladders, though very regular, yet differ in ſhape, ſize and ſituation; in ſome places like white rays, ſtreaming from the inner edge thereof outwards to the circumference of the bark, as is apparent in a tranſverſe ſection of lovage, melilot, parſnip, &c. continuing in direct lines the whole length of the root.

The bark, as before obſerved, is intermixed with a few lignous veſſels, which are apparent in moſt roots in the reſemblance of threads. Theſe tubular threads do not run in direct lines, but are frequently braced together in the form of network, as is apparent if the bark be ſtripped off, and a piece of it examined by the microſcope.

In parſnips theſe veſſels yield a thin lympha. It is certain that this clear ſap aſcends only in theſe veſſels, becauſe no liquor will do the like from any parenchymous part; ſometimes they yield a thick mucilaginous lympha as comfrey; oftentimes theſe ſucciferous veſſels yield a milky or white ſap, and ſometimes yellow, as in ſonchus, and moſt cichoraceous plants; in angelica, and moſt umbelliferous; in burdock and divers thiſtles; in ſcorzonera, common bells, and many other plants, not commonly taken notice of to be milky. Theſe milky ſaps, although of different colours, thickneſs, and other qualities, agree in being more oily than any of the lymphous ſaps; for the mixture of the oily parts, with ſome other limpid liquor,

quor, cauſes them to be of a milky [h], or other opake colour. In the ſame manner as common oil, and a ſtrong liquament of tartar, ſhook in a bottle, become white.

Sometimes the oil will ſeparate, as is obſervable on cutting a fennel root tranſverſly, after it hath lain ſome days out of the ground. The ſame veſſels, which before yielded milk, will now yield oil.

All gums and balſams are likewiſe the contents of theſe veſſels, for theſe and milks are nearly a-kin. The milk of fennel ſtanding ſome time, turns to a clear balſam, of ſcorzonera; dandelion, and others, to a gum. In the dried root of angelica, when ſplit, the milk [i] is ſeen in clods, in the continuation of theſe veſſels, condenſed into an hard ſhining roſin. The root helenium cut tranſverſly, preſently yields a balſam of a citron colour, ſo called becauſe it will not diſſolve in water. The root of common wormwood yields a true balſam, with all the defining properties of a terebinth; the roots of trachelium and enula, yield both a lympha and a citron balſam; and wormwood both a lympha and a terebinth [k] at the ſame time. It is doubtful whether all roots have lymphæducts, but probably they have, and for the moſt part ſtanding in a ring, at the inner verge of the bark.

The ſituation of theſe veſſels are very curious, if viewed in a tranſverſe ſection of the root; ſometimes they only form a ring at the inner edge of the bark, as at E F, in aſparagus, fig. 467. in which poſition they are in moſt, if not all roots; in ſome they ſtand in rays, as borage, or peripherial, as in celandine. Theſe vaſcular rays are extended in ſome towards the circumference of the bark, about half way, as between C D E F, in bugloſs, fig. 475. in all docks and ſorrels, about three fourths of the thickneſs of the bark towards the circumference, ſeveral

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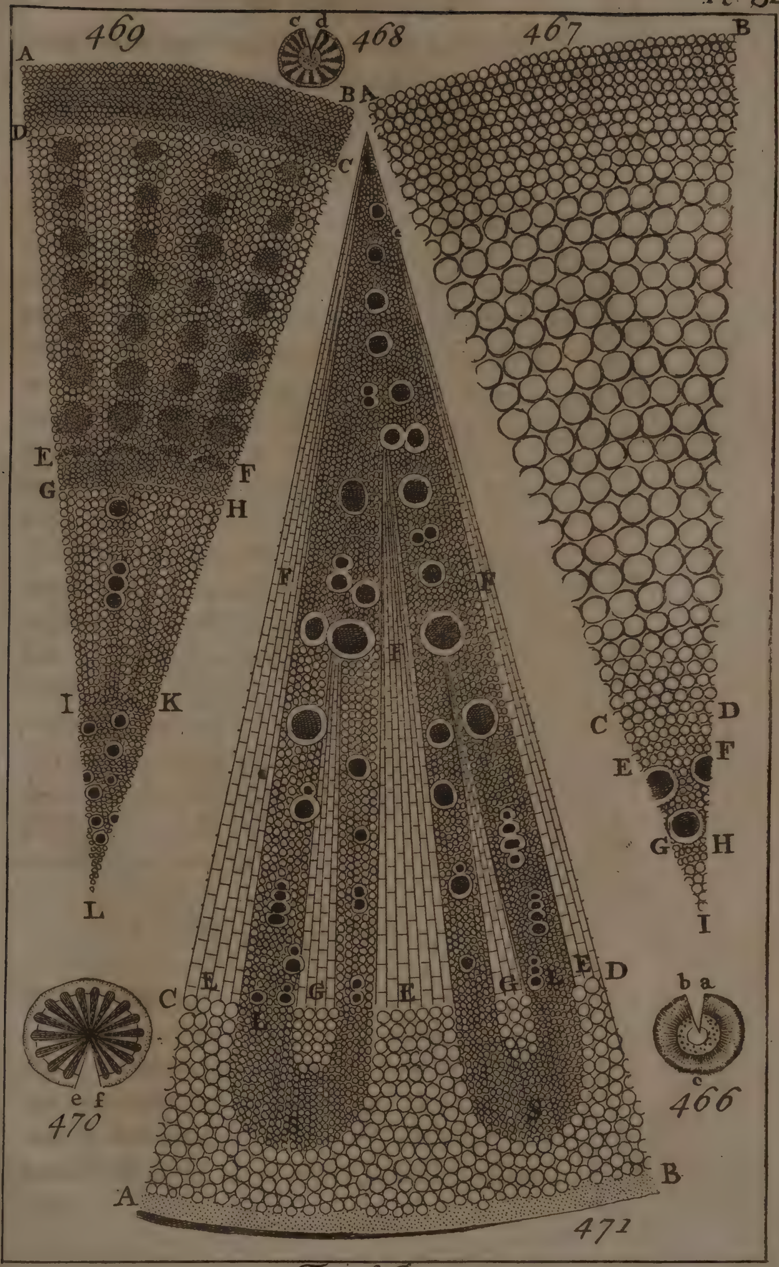
[h] Grew. An. Plant. p. 67. [i] Ibid p. 67. [k] Ibid. p. 68.

of them are alſo arched thereabout. In all, or many trefoils, and of the leguminous kind, only one third of the bark. In the umbelliferous, they are ſituate between the diametrical portions of the parenchyma. In the microſcope they all of them appear to be real circles; and in a tranſverſe ſection, when the milk has been licked off with the tongue, till no more will riſe. They may alſo be ſoaked in water, after which the poſition of the milk veſſels will be viſible; in ſome roots they run more parallel and keep aſunder, as in monks-hood, and join towards the circumference of the bark, in eryngo. They terminate more circular, in briony angular, or in the form of a glory, as will appear alſo on viewing an horſe-raddiſh root, C D E F G H I, fig. 473. in the microſcope. In ſome almoſt entire circles, as in dandelion; in others compoſed of ſhort chords; in ſome theſe ſpecks are ſo exceeding ſmall, that to the naked eye they ſeem continued rings, but when viewed in the microſcope, are diſtinct veſſels, as in marſh-mallows, and liquorice. In marſh-mallows the lymphæducts appear in rays, and the lacteals in rings, fig. 469. In dandelion they appear to the naked eye like numerous rings, but when viewed through the microſcope, are found to conſiſt of very many ſmall rays, ſtreaming from the inner verge of the bark, a-croſs three or four of the ſmaller rings.

Of the wood of roots.

THAT portion of the root, which is contiguous to, and within the bark; in trees, and ſhrubby plants, is the wood, which conſiſts of the parenchyma and lignous ſubſtance. The firſt of which is of the ſame nature with that of the bark. The poſition of its ſeveral parts are moſtly diametrical, running between the lignous parts,

Pl. 54



Front^{d}. Pag. 248 Bowles ſc.

parts, from the circumference towards the center of the root, and all together conſtitute that which is before called the inſertment. Theſe inſertments are moſt obſervable in the roots of many herbs, as comfrey, which exhibits a good notion of all other, as well trees as herbs; ſometimes this parenchymous body is diſpoſed into rings, as in fennel. In moſt woody roots, they ſtream between the pith and bark, like ſo many ſmall rays. In ſome roots they continue to the center, as columbine, in others not, as parſnip; and ſometimes different in the ſame root, as E F in the vine, fig. 471. They are compoſed of many ſmall bladders, as in the bark, but generally ſmaller. Their ſhape uſually round, but ſometimes oblong and oval, as in borage, or oblong and ſquare, as in the vine.

The lignous part alſo conſiſts of two kinds of bodies, ſucciferous, or lignous, and air veſſels. The lignous are of the nature with thoſe of the bark, and in a tranſverſe ſection of the root, emit a liquor as thoſe do. Theſe veſſels are no where interwove or braced together, but continue from one end of the root to the other.

The poſition of both theſe kind of veſſels is various, the ſucciferous or lignous are ſometimes ſituate in diametrical lines, as in the vine, fig. 471. and moſt trees, ſometimes oppoſite to the areal, as in beet, &c.

Of the pith of roots.

WIthin the woody part, is the pith, which is not common to all roots, for ſome have none, as nicotian, ſtramonium, and others. The pith, for the moſt part, eſpecially in trees, is a ſimple body, yet like the bark it is compounded, ſome ſucciferous veſſels being mixed with it, as in jeruſalem artichoke, horſe-raddiſh, &

&c. many roots that have no pith at their lower part, have one at the top, as columbine, lovage, &c. Their contexture by the microſcope, appears to be of the ſame general kind in all plants, both in the parenchyma of the bark, in the inſertment or diametrical portions, and in the pith, all being compoſed of bladders, which are of very different ſizes, ſeldom leſs than thoſe of the bark, as in aſparagus, fig. 467. but generally much bigger, as in horſe-raddiſh, fig. 473. their poſition ſeldom varies, but is uniform in a tranſverſe ſection of all parts of the root piled up evenly one over another. In an upright ſection they ſeem to run in direct trains, length-ways; they are for the moſt part orbicular, though in the larger roots ſomewhat angular. On obſerving theſe bladders with the microſcope, their ſides will be found to conſiſt of ſeveral ranks of exceeding ſmall fibres, lying for the moſt part evenly one over another, from the bottom to the top of every bladder, and running a-croſs alſo from one bladder to another. If the pith be cut with a ſharp razor, or penknife, and ſo applied to the microſcope, they will be ſeen diſtinctly.

All plants exhibit this ſpectacle, but thoſe beſt with the largeſt bladders; nor the ſame pith ſo well in any other condition, as when dry; becauſe then the ſap being voided, the ſpaces between the fibres, and the fibres themſelves are more diſtinctly ſeen. Yet it muſt not be dried after cutting, becauſe its ſeveral parts will thereupon coincide and become deformed, but to be choſen while the plant is growing, at which time it may be often found dry and not deformed; as in the trunks of common thiſtle, Jeruſalem artichoke, &c. cut off the white bottoms of the bladders of a bullruſh tranſverſly, and they will appear like a curious piece of needle-work. The whole body of a root therefore conſiſts of veſſels and fibres, and probably theſe fibres themſelves are tubular.

If you take the roots of vine, fennel, dandelion, plumb-tree, elder, willow, &c. and lay them for ſometime to dry, then cut off a thin ſlice of each tranſverſly, and place it before the microſcope, by pinching one edge thereof between the nippers, the light will then be trajected through the perforations of all the veſſels both great and ſmall, they are ſcarce ever viſible in the freſh ſlices of theſe roots.

A clear and elegant ſight of the fibres which compoſe the air veſſels, may be obtained by ſplitting a vine root, or a piece of oak, and may be ſeen in the ſide of the greater air veſſels, in the reſemblance of needle-work; the ſpiration of the fibres may be better obſerved in the trunk than in the root, and beſt in young plants, but not ſo well by cutting as ſplitting, or by tearing off ſome ſmall piece, through which they run; their confirmation being by this means not ſpoiled.

But in the leaves or tender ſtalks of all ſuch plants as ſhew upon breaking a kind of down or wool, they may be ſeen drawn out, and that ſometimes to the naked eye. This wool being nothing elſe but a certain number of fibres drawn out of their ſpiral poſition, appearing more or leſs in the leaves and other parts of moſt plants, as in the vine, ſcabious, &c. in the ſcales of a ſquil they are ſo eaſily ſeparable, as to ſhew the plate or zone into which the air veſſels are uſually reſolved, which is not one ſingle piece, but made up of ſeveral round fibres, running parallel, and knit together by other ſmaller ones tranſverſly in the form of a zone.

Of the trunks of trees.

THE trunk comes next under conſideration, which conſiſts of the bark, the wood, the inſertions or veins, and the pith.

The croſs ſhootings of the wood in trunks of ſeveral years growth appear in rings, ſo that we may judge by the number of rings of how many years[1] growth the tree is; in each of theſe rings is one circle of large open pipes, but the fewer of theſe the ſtronger the timber.

The pores of the wood in well-grown timber are very conſpicuous both in an upright and tranſverſe ſection thereof.

The lignous body in the trunks of herbs are extremely viſible in the microſcope, each fibre thereof being perforated with thirty, fifty, an hundred, &c. pores, as may be ſeen in a magnified piece of burdock, fig. 477. and although each fibre appears to the naked eye to be but one, yet when magnified we plainly find them to be compoſed of a number of fibres, or rather hollow tubes joined together, ſo what we call the woody part of a tree, notwithſtanding all its ſolidity, is nothing elſe but a cluſter of innumerable and extraordinary ſmall vaſcular fibres; ſome of which riſe from the root upwards, and are diſpoſed in form of a circle, and the others which Dr. Grew calls inſertions, tend horizontally from the ſurface to the center, in ſuch a manner as to croſs each other, and are interwove like the threads of a weaver's web.

Theſe inſertions are viſible on ſawing trees lengthwiſe, and ſhaving from thence very thin ſlices. They are alſo diſcernable at their entrance into the wood on ſtripping off the bark.

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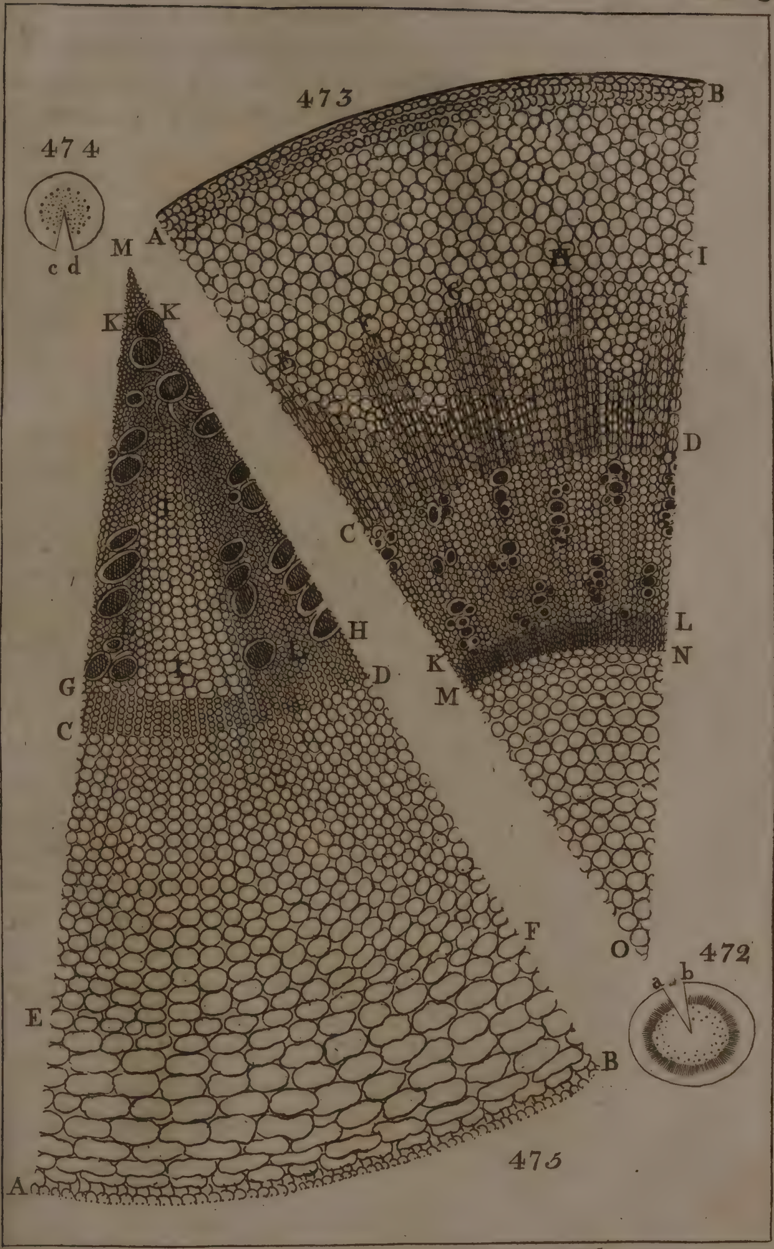
[1] Phil. Tranſ. No. 213.

Pl. 55



J. Wigley. Sc.

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As the pores or veſſels are greater or leſs, ſo are alſo the inſertions, to the naked eye, the largeſt only are diſcernable; but by the help of the microſcope they appear very numerous.

The inſertions in the trunk are viſible in a tranſverſe ſection, and are diſpoſed in even lines or rows throughout its whole breadth; they are repreſented as they appear in the root of a vine, when viewed through a microſcope, by E F, fig. 471.

The pores of the pith are moſtly obſervable in the trunk, being larger than in the root; and through a microſcope appear like ſo many bubbles or bladders, as in a piece of burdock, fig. 477.

In the piths of many roots and plants, ſome of the larger pores or bladders have ſmaller ones within them, ſome of which are divided with croſs membranes, and between their ſeveral ſides other ſmaller bladders are inſerted, in orderly ranks length-wiſe.

What Dr. Grew calls fibres and inſertments, or the lignous body interwoven with that which he takes to be the cortical, that is the ſeveral diſtinctions of the grain, are called by Mr. Liſter veins [m], that is, ſuch ducts as ſeem to contain and carry in them their nobleſt juices, analagous to human veins. Mr. Liſter makes it appear, that theſe veſſels are not the pores of the lignous body, from a tranſverſe ſection of angelica ſylveſtris magna vulgatior; the veins there clearly diſcovering themſelves to be diſtinct from the fibres, obſervable in the parenchyma of the ſame cortical body, the milky juices always riſing on the ſide, and not in any fibre. Alſo in a like inciſion of burdock, in June the juice ſprings on each ſide the radii of the woody circle, that is, in the cortical body and pith only; again where there is no pith none of this juice is obſerved.

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[m] Phil. Tranſ. No. 79.

In a tranſverſe cut of a leaf it is obſervable, 1. That theſe veins accompany the ribs and nerves. 2. That the middle fibre or nerve ſeems to yield one big drop of a milky juice ſpringing as it were from one vein, yet by the microſcope it is plain thēre are many veins, to the making up of that drop. 3. That if a fibre or nerve be carefully taken out of the leaf, the veins will appear therein like ſo many pipes running along the nerve, and yet theſe numerous veins are all of an equal bigneſs.

It is obſervable in the motion of theſe juices, that the milky juice always moves and ſprings briſkly upon the opening of a vein[n], the limpid ſap only at certain ſeaſons.

Dr. Grew aſſigns the offices of the ſeveral veſſels, viz. thoſe placed on the inner verge of the bark, he calls lymphæducts, and ſuppoſes them deſtined for the conveyance of the moſt watery liquor; theſe Mr. Bradley calls the new forming veſſels, which are annually produced, and help to increaſe the bulk of the tree.

Thoſe in the middle of the bark Dr. Grew calls lactiferous or reſiniferous veſſels: their uſe, according to Bradley, is to return the ſuperfluous ſap: theſe veſſels, Grew obſerves, are the principal viſcera of plants; and adds, that as the viſcera of animals are but veſſels conglomerated; ſo the veſſels of a plant are viſcera drawn out at length, all which will be eaſily underſtood by an inſpection of the following figures.

Fig. 476. repreſents a ſmall piece cut out of a walking cane, as it appeared in the microſcope. A B E F ſhews a tranſverſe ſection thereof, wherein are ſeen cluſters of air veſſels ſurrounded with rings of ſap veſſels, and at

A B C D

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[n] Phil. Tranſ. No. 90.

A B C D the pores in the outſide ſkin or bark of the cane are plainly viſible.

Fig. 477. repreſents a magnified piece of the ſtalk of burdock cut tranſverſly and down the ſide.

Fig. 478. exhibits a piece cut out of a branch of pine, wherein at A B C D is ſeen the bark ſide-ways, and at A B F E a tranſverſe ſection thereof, through which the turpentine veſſels run lengthwiſe. G H repreſents one of them cut down the middle to ſhew the inſide of it, and another is ſeen intire at I K.

Fig. 479. repreſents the milk veſſels in the bark of ſumach, in the ſame manner as the turpentine veſſels are repreſented in the foregoing figure, and are expreſſed by the ſame letters alſo.

Fig. 480. repreſents part of a vine branch cut tranſverſly; and fig. 481. a piece cut out of the ſame at a b, as it appeared in the microſcope; whereof A B C D ſhews the ſkin length-ways. At A B E F is ſeen a tranſverſe ſection of the wood and air veſſels, and between G H and I K part of the wood and bark is taken away to ſhew the ſame lengthwiſe.

Fig. 482. a, is a tranſverſe ſection of an apple branch, in which the ſeveral circles of wood that ſhew of how many years growth the tree is, are viſible to the naked eye. Fig. 482. b, repreſents a gore cut out of the aforeſaid ſlice at a b, as it appeared in the microſcope; in which A B repreſents the ſkin: A B C D the Bark: H I ſpiral ſap veſſels in arched parcels: O O the common ſap veſſels which begin to turn into wood: C D E F the wood of three years growth: K L M N one year's growth, in which the dark ſpots repreſent the air veſſels: g g g the true wood: P P the inſertions: E F other ſap veſſels: E F G the pith.

Fig. 483. ſhews a tranſverſe ſlice of a hazel branch, and fig. 484. repreſents a piece thereof, which was cut out at c d, as it appeared when placed in the microſcope, A B the ſkin: A B C D the bark: Q Q Q the ſimple parenchyma: H I a ring of ſpecial veſſels: P P common ſap veſſels: C D E F the wood of three years growth: K L M N one year's growth: X X X great inſertions: P O leſſer between them, the black parcels between theſe inſertions are the wood, which is compoſed of minute tubes (although it is here repreſented in a ſhade) in which the dark ſpots are the air veſſels: E F G the pith.

Fig. 485. exhibits a tranſverſe ſlice of a walnut branch, and fig. 486. a microſcopic picture of a gore thereof cut out from e f, in which A B is the ſkin: A B C D the bark: R R the parenchyma: H R I two rings of ſpecial ſap veſſels: D C common lymphæducts: D C E F the wood of four years growth: d d d the true wood: K L M N one year's growth; Q ſecond part thereof whiter than the reſt, by the mixture of ſap veſſels, which are repreſented by tranſverſe lines: M N the great air veſſels: c e, c e parcels of leſſer ones: E F a ring of other ſap veſſels: E F G the pith.

At fig. 487. is ſeen a ſlice of a branch of pine cut tranſverſly, and at fig. 488. a magnified piece of the ſame cut out from g h. A B C D the bark: M M M the parenchyma: D L C the lymphæducts: H H turpentine veſſels: D C E F the wood in which the white ſpaces tending to the center ſhew the inſertions: E F G the pith, the larger holes both in the wood and pith are more turpentine veſſels.

Fig. 489. repreſents a tranſverſe ſection of a wormwood ſtalk, from whence a piece i k was cut, which is exhibited as it appeared in the microſcope, by fig. 490. whereof A B C D is the bark: A M B the parenchyma:

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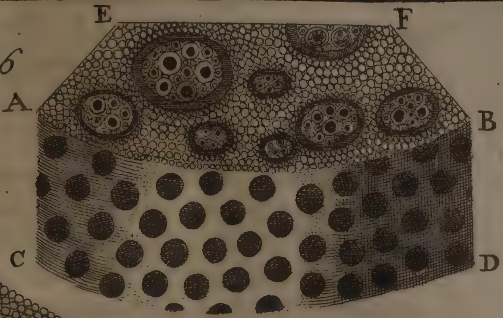

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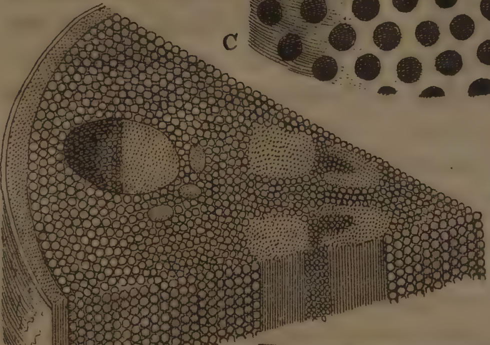

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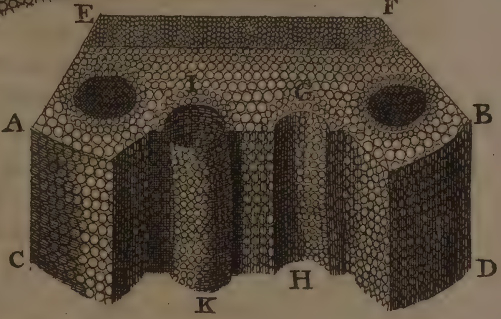

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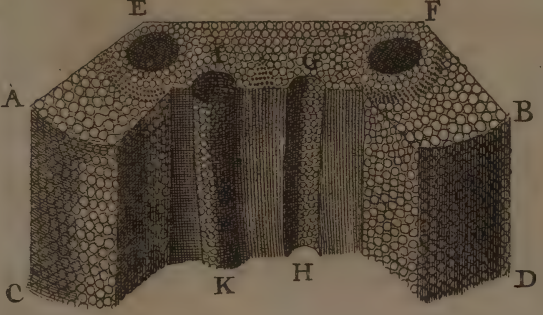

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H M I balſamic veſſels: K L another ſort of ſap veſſels in parcels: K L C D lymphæducts: D C E F the wood in which the dark ſpots, are the air veſſels: M M the inſertions: R another balſamic veſſel: E F G the pith.

Fig. 491. is a tranſverſe ſection of a thiſtle-ſtalk, out of which at l m was cut a piece, which is ſeen as it appeared in the microſcope at fig. 492: A B C D the bark: H I the parenchyma: e e a ſort of ſap veſſels: a a another ſort: c c milk veſſels: D C E F the wood: V V the air veſſels: t t more lymphæducts: ſ ſ mere milk veſſels: a t inſertions: E F G the pith compoſed of angular bladders, bladders of threads, and threads of ſingle fibres.

Fig. 493. ſhews a tranſverſe ſection of ſumach ſtalk, and fig 494. a magnified gore thereof, which was cut out at n o. A B a a the hairy ſkin: A B C D the bark: H W I the parenchyma: D M C the common lymphæducts: K M L three milk veſſels: H I another ſort of lymphæducts, arched over the milk veſſels: X X ſeems to be a third ſort of lymphæducts: D C E F the wood, the white rays tending from M to M are the inſertions: Y Y the true wood in which the dark ſpots, are air veſſels: E F a ring of lymphæducts: E F G the pith.

Fig. 495. repreſents part of a vine branch cut tranſverſly at A B G, and A B C, and alſo ſplit half way down the middle at G G B B, whereof A B A B is the ſkin: A B C D, A B C D the bark: H H H ſap veſſels in arched parcels: I the parenchyma: C D E F the wood: d d d the true wood, in which the dark ſpots, are the air veſſels: K K the inſertions: E F a ring of other ſap veſſels: E F G the pith: between G G, F F, is ſhewn the poſition of the bladders in perpendicular rows: between D D and B B is ſeen the ſame of the bark; and between F F D D is ſeen an upright ſection of the wood and air veſſels.

Of the bark of trees.

THE exterior part of trees is the bark, and ſerves them for a ſkin or covering; in general it is of a ſpongy texture, and by many little fibres, which paſs through the capillary tubes whereof the wood conſiſts, communicated with the pith; ſo that the proper nutriment of the tree being imbibed by the roots, and carried up through the fine arterial veſſels of the tree by the warmth of the ſoil, &c. to the top of the plant, is uſually ſuppoſed to be there condenſed by the cold air; and returns by its own gravity down the veſſels, which do the office of veins, lying between the wood and inner bark, leaving, as it paſſes by, ſuch parts of its juice as the texture of the bark will receive and requires for its ſupport. That ſoft whitiſh rind or ſubſtance, between the inner bark and the wood, which, Mr. Bradley thinks, does the office of veins; ſome account a third bark, differing only from the others in the cloſeneſs of its fibres; it is this contains the liquid ſap, gums, &c. found in plants in the ſpring and ſummer months. It hardens by little and little, by means of the ſap it tranſmits, and is imperceptibly converted into the woody part of the tree. There are few trees but what have it; yet it is ſtill found in leſs quantity as the tree is more expoſed to the heat of the ſun. It is here the corruption of trees generally begin; whence thoſe who fell and cut trees ought always to take care to leave as little of it on as poſſible.

The bark conſiſts of two parts, the utmoſt ſkin and the main body; the ſkin is generally compoſed of very ſmall veſicles

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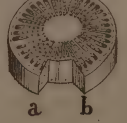

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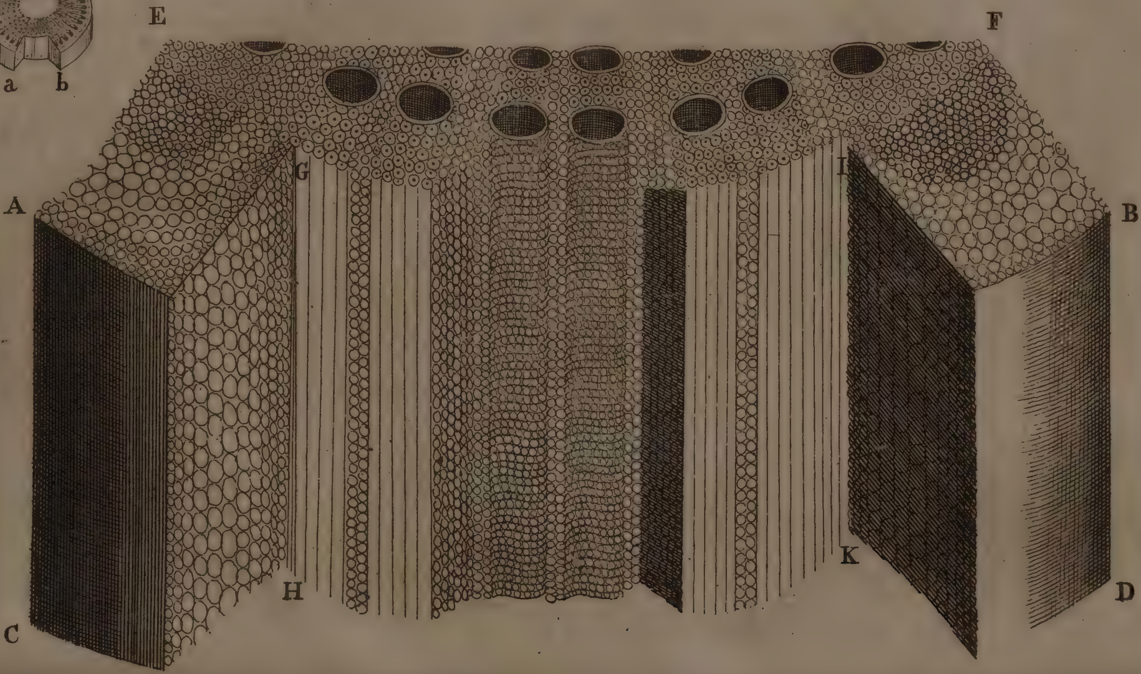

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veſicles or bladders; but as the plant grows, the ſkin dries, and the bladders ſhrink up and diſappear. Amongſt theſe ſkinny bladders are intermixt a ſort of woody fibres, as in mallow, nettle, borage, thiſtle, and moſt herbs.

The ſkin of the trunk is ſometimes viſibly porous, as in the better ſort of walking canes, fig. 476. A B C D.

The main body of the bark alſo conſiſts of two parts, the parenchyma and veſſels; the parenchyma is compoſed of an infinite number of ſmall bladders, and the veſſels are very numerous, ſtanding in or near the inner margin of the bark, and are always ſap veſſels [o].

The properties of the ſaid veſſels are diſtinguiſhed from one another in the ſame plant, and in the ſeveral ſpecies of plants; which properties are not accidental, but ſuch as ſhew the conſtant and univerſal deſign of nature.

For in the figures 482, 484, 486, 488, the veſſels of the bark are only of two kinds, which in the firſt two ſeem to be roriferous [p] and lymphæducts (yet in all the four their number and poſition is very different.) In hazel, fig. 484. they are but few; in apples, fig. 482. they are more, and alſo in pear, plumb, elm, &c. ſtill more numerous. As to their poſition in hazel, the lymphæducts, or veſſels next the wood, ſtand in ſemicircular parcels; and in holly they ſtand in rays, yet ſo numerous and cloſe together as to make one intire ring. In the apple branch, fig. 482. the lymphæducts O O are radiated, they are alſo radiated in the pear and plumb, &c. In hazel, fig. 484. the roriferous veſſels H I, as Dr. Grew calls them, make an entire ring. In apple, fig. 482. they are neither radiated nor make an intire ring, but ſtand in peripherical parcels, much after the ſame manner they ſtand in elm. In aſh the veſſels make two rings, the inmoſt or lymphæducts conſiſt in arched parcels, and the outmoſt or rorife-

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[o] Grew Ana. Plant. p. 108. [p] Ibid. 109.

rous of round ones; whereas in the foregoing the lymphædµcts are contiguous to the wood, and the roriferous more or leſs diſtant from the ſkin; here, on the contrary, the firſt are diſtant from the wood, and the latter contiguous to the ſkin.

In the two next branches, fig. 486 and 488. the veſſels of the bark are alſo different in number, poſition, ſize and kind. In pine they are leſs, and in walnut more numerous; as to their poſition, the inmoſt D C in pine, fig. 488. compoſe a radiated ring, the utmoſt are ſtraggling up and down without any certain order. In walnut, fig. 486. the inmoſt D C make alſo a radiated ring, and the outmoſt a double ring H R I, not radiated but of round parcels: as to their kind, they differ moſt apparently from the diverſity of ſaps thoſe different veſſels contain; which in the bark of pine, fig. 488. are alſo of two ſorts, the inmoſt are lymphæducts, as in the two former; the outmoſt are not milk, but gum veſſels, or reſiniferous, and ſtand ſtraggling or ſingly about the bark; all the clear turpentine that drops from the tree iſſues from theſe veſſels, which are apparent even to the naked eye; whereas thoſe of the lymphæduct are not to be diſcerned without the aſſiſtance of a microſcope.

The two next pieces of branches are common ſumach, fig. 494. and common wormwood, fig. 490. which are remarkable for their having three kind of veſſels in the bark, whereas the former have only two. Firſt then in common ſumach is a thick radiated ring D M C of lymphæducts, ſtanding on the inner margin of the bark contiguous to the wood; theſe veſſels exhibit their lympha very apparently. The ſecond kind of veſſels X X compoſe a ring, and are ſituate near the outward margin of the bark. Between theſe two kinds ſtand the milk veſſels K M L, each of which being empaled or hemm'd in by an arch of roriferous veſſels.

The next is a branch of common wormwood, fig. 490. in the bark of which are alſo three kinds of veſſels; firſt there is a thin radiated ring C D L K of lymphæducts, contiguous to the wood, yet this ring is not entire, but made up of ſeveral parcels; which are intercepted by as many parenchymous ones, inſerted from the bark into the pith. The ſecond ſort of veſſels K L, which ſeem to be roriferous, are ſituate near the middle of the bark, and ſtand in arched parcels; theſe alſo compoſe a ring.

Beyond theſe arches, and towards the outer margin of the bark, ſtand a third ſort of veſſels H M I, their content is a kind of a liquid, oleous and viſcid gum, which for its pleaſant flavour may be called an aromatic balſam [q], becauſe it perfectly affordeth whatever is in the ſmell or taſte of wormwood, being the eſſence of the whole plant, ſo that they are in all reſpects analogous to the turpentine veſſels in pine.

The ſtructure of the milk and gum veſſels when viewed with the microſcope, ſeem to be made by the conſtipation of the bladders in the bark, that is to ſay, they are ſo many channels, not bounded by any ſides proper to themſelves, as a quill thruſt into a cork, or as the air veſſels in the wood, but by the bladders of the parenchyma [r], which are ſo crowded up together, as to leave certain tubular ſpaces throughout the whole length of the bark.

One difference between thoſe veſſels juſt deſcribed, and theſe hollow tubes, &c. in the pith, is this, that they are not originally formed with the pith, but are formed partly by the ſtretching it undergoes from the dilatation of the

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[q] Grew Ana. Plant. p. 111.

[r] Ibid. p. 113.

wood, and partly from the drying and ſhrinking up of its bladders, and of their component fibres; whereas the veſſels in the bark are many of them originally formed [s] therewith; and thoſe which ſucceeded them are not cauſed by any rupture as thoſe in the pith are, but from a regular diſpoſition of the parenchymous fibres, and conſtipation of the bladders thereof; all which will appear very plain upon viewing the three figures 477, 478, and 479.

It has been before obſerved, that the lignous or towy parts of all plants are tubular, and that the juices are conveyed the whole length of the plant through an infinite company of ſmall tubes.

Theſe very tubes or lymphæducts are likewiſe made up of other yet much ſmaller tubes, ſet round together in a cylindrical figure; by which alſo appears the admirable ſmallneſs of theſe fibres; for there are ſome lymphæducts that may be reckoned fifty times ſmaller [t] than an horſe-hair, and thoſe minute fibres are alſo compoſed of other ſuch fibres, but much ſmaller, is not altogether improbable; allowing therefore but twenty of theſe to compoſe a thread no bigger than one of theſe lymphæducts; then one of theſe fibres muſt be thouſand times ſmaller than an horſe-hair.

They may be obſerved in a very white and clear piece of aſh torn carefully lengthways, and ſometimes alſo in a very white piece of fir.

In the Eaſt Indies they manufacture the bark of a certain tree into a kind of ſtuff or cloth; it is ſpun and dreſſed much after the manner of hemp: the long filaments which are ſeparated from it, upon beating and ſteeping it in water, compoſe a thread of a middle kind between ſilk and common thread, neither ſo ſoft or bright as ſilk, nor ſo hard or flat as hemp. Some of theſe ſtuffs are pure bark, and are called pinaſſes, biambonnes, &c. In others they mix ſilk with the bark, and call them ginghams and nillas; the fontalungees too, are part ſilk, part bark, and are only diſtinguiſhed by being ſtriped.

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[s] Grew. Ana. Plant. p. 113.

[t] Ibid. p. 112.

Of the wood.

THE next general part of a branch is the wood which lies between the bark and pith; it is compoſed of parenchymous and lignous parts. The parenchymous part of the wood in all trees, though much diverſified, is diſpoſed into many rays or inſertions running between as many woody portions, from the bark to the pith. Theſe inſertions are various according to the ſeveral ſorts of trees or plants, in pine, fig. 488. and wormwood, fig. 490. they are not ſo numerous as in ſumach, fig. 494. in the apple, fig. 482. or in the hazel, fig. 484.

Theſe inſertions do not run only through the wood, but alſo ſhoot out beyond it into ſome part of the bark, as in elm, ſumach, wormwood, &c.

The texture likewiſe of theſe inſertions is alſo various in wormwood and moſt herbs, they are manifeſtly compoſed of ſmall bladders, yet larger in theſe than in trees.

The wood is likewiſe compoſed of two ſorts of bodies, that which is ſtrictly woody, and the air veſſels. The true wood is nothing elſe but a maſs of antiquated lymphæducts, viz. thoſe which are originally placed on the inner margin of the bark; for in that place there annually grows a new ring of lymphæducts, which by degrees loſing its firſt ſoftneſs, is at the latter end of the year turned into a dry and hard ring of perfect wood. Whence it is evident that the bark of a tree is divided into two parts, and diſtributed two contrary ways; the outer part falleth off towards the ſkin, and at length becomes the ſkin itſelf. The outward ſkin of a tree is not originally made a ſkin, but was once ſome of the middle part of the bark itſelf, which is annually caſt off and dried into a ſkin; the inmoſt portion of the bark is yearly diſtributed and added to the wood, the parenchymous part thereof makes a new addition to the inſertions within the wood, and the lymphæducts a new addition to the woody pieces between which the inſertions ſtand; ſo that a ring of lymphæducts in the bark this year will be a ring of wood the next, and another ring of lymphæducts and of wood ſucceſſively from year to year; ſo in fig. 482. of part of an apple branch cut tranſverſly, three years growth are repreſented in that of ſumach, fig. 484. one year only is exhibited, and in that of walnut, fig. 486. are ſhewn four years growth of wood between the letters D C E F.

Here alſo may be obſerved, that certain parcels of wood make either ſeveral ſmall white rings, as in oak, or ſeveral white and crooked parcels tranſverſe to the inſertions, as at D C, K L, &c. in walnut, fig. 486.

In the branches of fir, pine, &c. are a few turpentine veſſels diſperſed up and down the wood. The air veſſels with the inſertions, and true wood altogether, make up that which is commonly called the wood of a tree.

The variety of the air veſſels are many, with reſpect both as to their number, ſize, and poſition, and are not to be found alike in any two ſorts of plants whatſoever: as to their number it is very great, in apple, pear, hazel, &c. but in different degrees, they are repreſented by all the black ſpots in the wood, in all the figures before referred to.

Their ſizes are as different as the trees to which they belong, being at leaſt twenty times bigger in elm or oak, than in holly or pear, &c.

Their ſituation is alſo different: in apple, fig. 482. and in walnut, fig, &c. they are ſpread abroad in every annual ring; in others they keep more in the compaſs of ſome line or lines, either diametrical or peripherical. In holly, &c. they are radiated or run in even diametrical lines between the pith and bark.

Whether the air veſſels are irregular or radiated, nature hath ſo diſpoſed them, as that many of them ſtand always near the inſertions.

In aſh the air veſſels ſtand in circles on the inner margin of every annual ring. Theſe circles are in ſome very thick, as in aſh and barberry, in ſome thin, as elm, &c.

Their form is ſuch that they are never ramified, but continued from one end of a plant ſmall or great, quite through to the other end thereof.

As to their texture they oftentimes appear to be unwreathed in form of a very ſmall plate, which alſo is not only of different breadths in different plants, and uſually broader in the root than in the trunk; but alſo the ſaid veſſels are oftentimes unwreathed, not in the form of a plate but of a round thread. The cauſes of which diverſity are principally three, the weſtage of the fibres of which the air veſſels conſiſt; the difference between the ſaid fibres, or between the warp and woof, and the different kinds of woof.

By the weſtage of the fibres it is, that the veſſels oftentimes untwiſt in the form of a plate; as if a fine narrow ribband be wound ſpirally, and edge to edge, about a ſtick, and then the ſtick being drawn out, will leave the ribband in the form of a tube [u] and of one of theſe air veſſels, for that which upon the unwreathing of the veſſel ſeems to be a plate, is as it were a natural ribband, conſiſting of a certain number of threads or round fibres, ſtanding parallel as the threads do in a ribband; and as in a ribband ſo here, the fibres which make the warp and run ſpirally, do not grow together, but are held in that poſition by other tranſverſe fibres which embrace them, and are in the place of the woof.

And as the ſaid fibres are tranſverſly continued, thereby making a warp and woof, ſo are they (as in divers woollen manufactures) of different bulk; thoſe of the former being ſtronger and bigger than thoſe of the latter; by which means, as cloth and ſilk will uſually tear ſooner one way than another; ſo here while the warp, or thoſe fibres which run ſpirally are unwreathed, without breaking the ſmaller ones which hold them together, eaſily tear all the way.

In the following figures are ſhewn the poſition of the veſſels in ſeveral ſorts of timber cut length-wiſe and croſs-wiſe as follows:

Fig. 507. repreſents a ſmall piece of the wood of an oak-tree, cut tranſverſly, and of its natural ſize; and fig. 508. A B C D, ſhews the ſame piece as it appeared before the microſcope when greatly magnified, whereof the parts F F ſeemed to be brown dark ſtreaks, the wood included between the ſpaces H I and K L, is the breadth of that circle which the tree had increaſed in one year. E E are the cavities of very large air veſſels, which run the lengthway of the tree. Theſe large veſſels are compoſed of ſeveral ſmaller membranes, as may be ſeen at fig.

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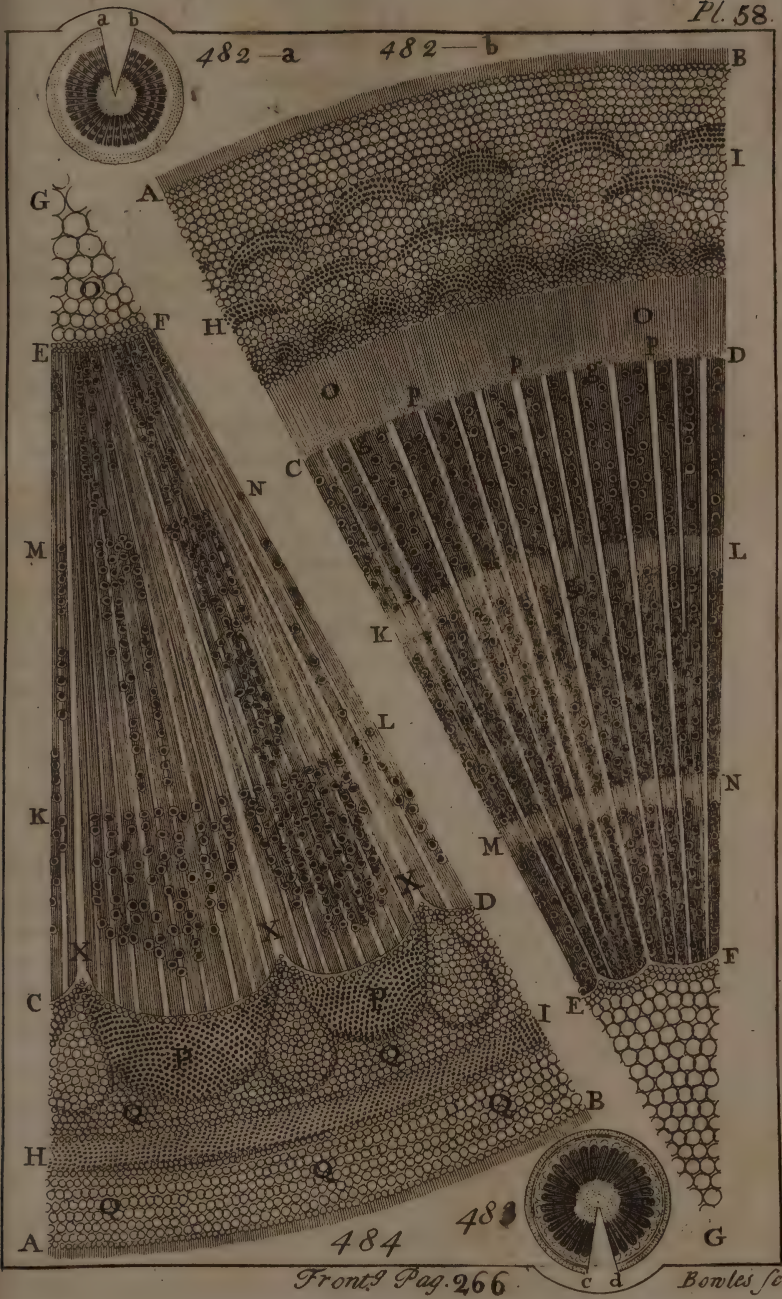
[u] Grew Ana. of Plant. p. 117.

Pl. 58.



Front.^s Pag. 266 *Bowles ſc.*

fig. 512. which repreſents part of one of the aforeſaid air veſſels ſeen length-wiſe, and as it appeared before the magnifier.

The ſecond ſort of perpendicular veſſels which tend upwards, are ſeen at e e, fig 508. and are alſo compoſed of exceeding fine ſkins [x], in which are ſeen ſome ſpots that in the microſcope appear like globules, as at O N, fig. 511. which ſhews one of theſe ſecond ſort of veſſels cut lengthwiſe.

The third ſort of theſe veſſels which run upwards, are extremely ſmall and in great abundance, as appears throughout the whole ſpace H I K L, fig. 508. Theſe alſo are compoſed of extremely fine ſkins; they are ſeen length-ways between P Q, fig. 511.

G G G, fig. 508. are another ſort of veſſels, which run horizontally from the bark to the pith: theſe ſeemed to extend themſelves in furrows, and were crooked or bowed round the knots. When the wood is cut lengthwiſe, theſe horizontal veſſels are cut acroſs, as at G G G, fig. 511. The ſecond ſort of horizontal veſſels are greatly numerous, which when the oak is cut length-wiſe, are alſo cut acroſs, and appear to the naked eye as fig. 513.

Fig. 496. ſhews a piece of elm cut tranſverſly as it appeared to the naked eye; and fig. 497. a microſcopic picture of the ſame. A B, C D is the breadth of the ring the tree had increaſed in one year. The ſmaller perpendicular veſſels are ſituate between and joined to the larger, having ſmaller ones between them, as in oak; the tubes here alſo are compoſed of ſkinny membranes. A C and B D, fig. 497. are horizontal veſſels ſeen lengthwiſe. Fig. 498. is an upright ſection of the wood of elm magnified, in which G G ſhews the exceeding ſmall

veſſels length-ways, H H is the cavity of one of the great veſſels, being full of turpentine threads, or little tubes, with black ſpots curiouſly wove together; as at fig. 499.

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[x] Leeuwenhoek's Anat. & Contemp. Vol. I. p. 3.

Fig. 500. is a ſmall and thin piece of beach, cut tranſverſly, and fig. 501. repreſents the ſame as it appeared in the microſcope. Its length between A B and D C is the breadth of a circle of one year's growth. The perpendicular veſſels in this wood are of two, the horizontal ones of three ſizes; of which thoſe expreſſed by E E, fig. 501. are exceeding ſmall; in the upright ſection, fig. 502. theſe horizontal veſſels are cut tranſverſly, and ſhewn by H H, the ſecond ſort of horizontal veſſels are ſeen lengthwiſe, from D to A, fig. 501. and a tranſverſe ſection of the ſame veſſels are ſeen in the upright ſection of the timber, fig. 502. at I, I, I, and at K K are ſeen the great perpendicular veſſels.

Fig. 509. repreſents a tranſverſe ſection of a ſmall bit of black ebony, greatly magnified, of which G, G, G, are the large upright veſſels. K K, in fig. 510. ſhews one of theſe large veſſels cut lengthwiſe, and at fig. 511. is ſeen another of a larger ſort, in which are many ſtreaks and ſpots. The ſecond ſort of perpendicular veſſels are ſeen between A B, A B; and the third ſort between C D, C D; a fourth ſort are ſquariſh, and included between the ſecond and third in the upright ſection, fig. 510. L L ſhews the ſmalleſt veſſels, and I, I, the tranſverſe ſections of the horizontal ones.

Fig. 503. A B C D is a ſmall piece of box, cut tranſverſly, and of the ſame ſize to the naked eye as the piece of ebony. This wood alſo conſiſts of large and ſmall perpendicular veſſels intermixed; the large ones are compoſed of ſkins, and are full of extremely minute particles, as may be ſeen in the upright ſection thereof at E E, fig. 504. the cavities of the leſſer veſſels are ſhewn lengthways

at F E. A B and C D, fig. 503. are horizontal veſſels, running lengthways, and at G G, fig. 504. is ſeen a tranſverſe ſection of the ſame.

A B C D E F, fig. 505. repreſents a tranſverſe ſection of a ſmall piece of ſtraw. A B E F is the ſhining bark, compoſed of an incredible number of exceeding ſmall veſicles. G G G G are veſſels, or rather bladders, having four, five, or ſix ſides, and compoſe the greateſt part of the inſide of the ſtraw. H H H are ſome of the before-mentioned veſſels, intermixed with, or ſurrounded by a great number of exceeding ſmall veſſels. At fig. 506. the ſame veſſels are ſeen lengthways in a perpendicular ſection of the ſtraw.

Of the pith.

THE third general part of a branch is the pith, being in ſubſtance nearly allied to the parenchyma in the bark, and the inſertions in the wood.

Its ſize is various, not being the ſame in any two branches here repreſented. In wormwood, fig. 490. and ſumach, fig. 494. it is very large. In pine, fig. 488. and walnut, fig. 486. not ſo large. In apple, fig. 482. and hazel, fig. 484. it is ſmaller.

It is alſo remarkable, that the bark and wood in moſt plants increaſe yearly; and the pith, on the contrary, grows ſmaller.

The pith, for the moſt part, is furniſhed with a certain number of ſap veſſels, which form a ring round the margin thereof. They are numerous and conſpicuous in walnut, fig. 486. and in pine, fig. 488. &c. and are of divers kinds, being lymphæducts in walnuts, lacteals in fig, and reſiniferous in pine.

The parenchyma of the pith is compoſed of bladders the very ſame with thoſe in the bark, and oftentimes in the inſertions within the wood; only theſe of the pith are largeſt, thoſe in the bark leſs, and theſe in the inſertions leaſt of all.

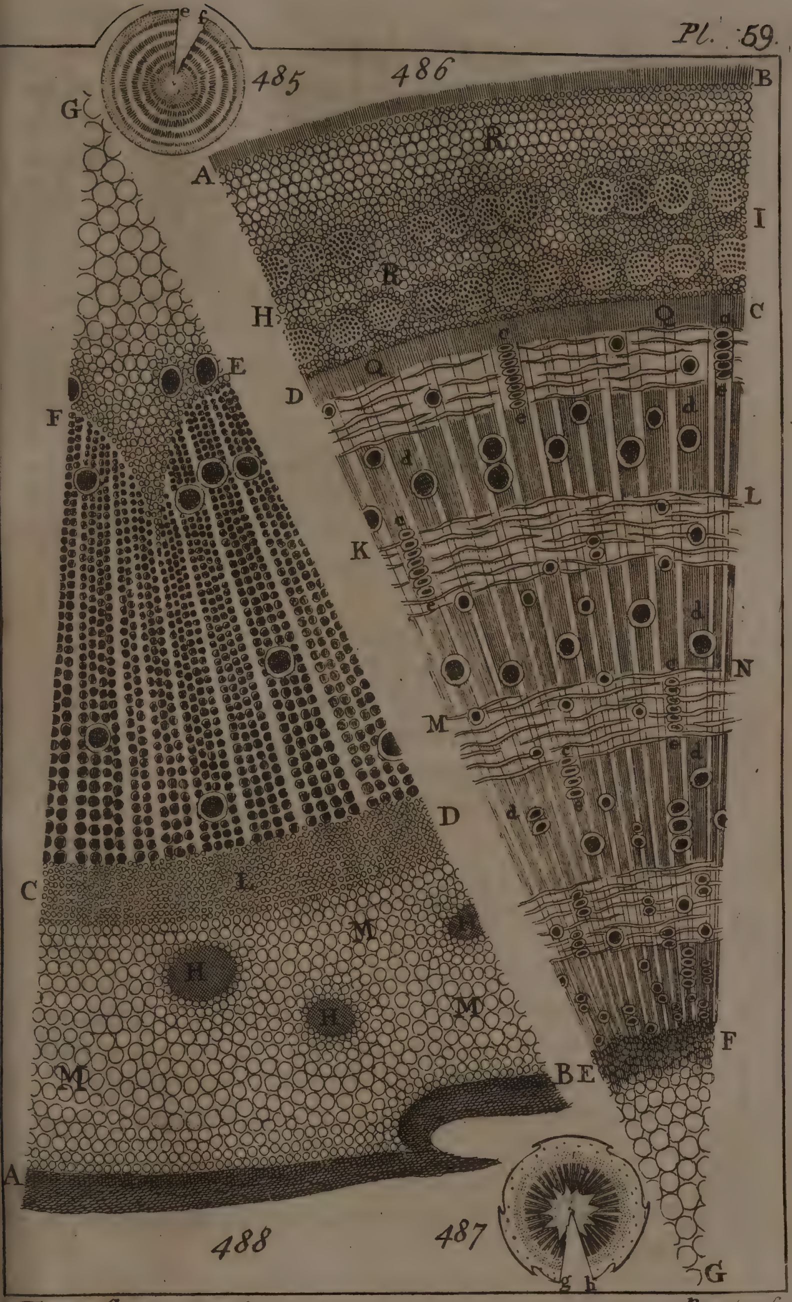
The bladders of the pith, though always comparatively great, are of very different ſizes. Thoſe of thiſtle, borage, &c. appear in the microſcope like the cells of an honey-comb; the bladders in common thiſtle and borage, are ſo large as to contain within their horizontal area, about twenty bladders of the pith of oak. Wherefore one bladder in thiſtle is at leaſt an hundred times bigger than another in oak.

The ſhape of the pith bladders admit of ſome variety; they are for the moſt part round, yet oftentimes angular, as in reed graſs, a water plant; where they are alſo cubical; in borage, thiſtle, and many others they are pentangular, ſexangular, and ſeptangular.

As to the texture of theſe pithy bladders, they are oftentimes compoſed of ſmaller ones, as in borage, bulruſh, and many other plants.

Whence it appears, that as the veſſels of plants, viz. the air veſſels and lymphæducts, are made up of fibres, ſo the pith, or the bladders of which the pith conſiſts, are likewiſe compoſed of fibres, which is alſo true of the parenchyma of the bark, and of the inſertions in the wood, and even of the fruit, and all other parenchymous parts of a plant, and that the very pulp of an apple, pear, cucumber, plumb, or any other fruit, is nothing elſe but a ball, of moſt extreamly ſmall tranſparent threads or fibres, joined together in a different, but curious manner, even all thoſe parts of a plant, which are neither formed into viſible tubes, nor bladders, are made up of fibres; and though it be difficult to diſcover them in thoſe parts which

Pl. 59.



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which are the moſt compact and cloſe, yet in the pith which conſiſts of more open work, they are viſible; and that in the pith of a bulruſh, common thiſtle, &c. not only the threads of which the bladders, but alſo the ſingle fibres of which the threads are compoſed, may be diſtinctly ſeen, when placed before the microſcope.

The fibroſity of the parenchyma is alſo viſible in ſome woods, being interwove with the lignous parts, and with every fibre of every veſſel, as in very white aſh or fir, may be diſcovered.

Whence it follows, that all the parts of a plant conſiſt of fibres, of which thoſe of the lymphæducts run lengthwiſe, thoſe of the pith, inſertions, and parenchyma of the bark horizontally, thoſe of the air veſſels begin their circuit horizontally, and continue it in height or lengthwiſe.

From what has been ſaid, there appears to be a great ſimilitude between the mechaniſm of plants and animals, the parts of the former ſeem to bear a conſtant analogy to thoſe of the latter; and the vegetable and animal œconomy ſeem to be both formed on the ſame model; for from the foregoing obſervations, and the aſſiſtance of the microſcope,

Firſt, the root is found to be a ſpongy body, whoſe pores are diſpoſed to admit certain humid particles, prepared in the ground.

Second, the wood which conſiſts of capillary tubes running parallel from the root throughout the ſtalk, (the apertus of thoſe tubes are too minute to come under the cognizance of the naked eye) theſe Mr. Bradley calls arterial veſſels; it being through theſe that the ſap riſes from the root.

Third, beſides theſe there are other larger veſſels, diſpoſed on the outſide of the arterial veſſels between the wood and the inner bark, and leading down to the covering of the root, which he alſo calls venal veſſels, and ſuppoſes them to contain the liquid ſap found in plants in the ſpring.

Fourth, the bark being of a ſpongy texture, which by many little ſtrings communicates with the pith.

Fifth, the pith, or pecten, which conſiſts of little tranſparent globules, chained together ſomewhat like the bubbles that compoſe the froth of liquor.

Malpighi was the firſt who obſerved, that vegetables conſiſt of two ſorts of veſſels. 1. Thoſe abovementioned, which receive and convey the alimental juices. 2. Tracheæ, or air veſſels, which are long hollow pipes, wherein air is continually received and expelled, i. e. within which tracheæ he ſhews all the former ſeries of veſſels are contained.

Hence it follows, that the heat of a year, nay of a day, of a ſingle hour, or minute, muſt have an effect on the air, included in theſe tracheæ, i. e. it muſt rarify it, and conſequently dilate the tracheæ; whence alſo muſt ariſe a perpetual ſpring or force of action to promote the circulation in plants.

For by the expanſion of the tracheæ, the veſſels containing the juices are preſſed; and by that means the contained juice is continually propelled, and ſo accellerated; by which ſame propulſion the juice is continually comminuted and rendered more and more ſubtle, and ſo enabled to enter veſſels ſtill finer and finer; the thickeſt part of it being at the ſame time ſecreted and depoſited into the lateral cells, or loculi of the bark, to defend the plant from cold and other external injuries.

The juice being thus conveyed from the root, to the remote branches, and even to the flower; and having in every part of its progreſs depoſited ſomething both for aliment and defence, what is redundant paſſes out into the bark, the veſſels whereof are inoſculated with thoſe wherein the ſap is mounted; and through theſe it deſcends to the root, and thence to the earth again, and thus is circulation effected.

Thus is every vegetable acted on by heat during the day-time, and the ſap veſſels thus are ſqueezed and preſſed, and the ſap protruded and raiſed, and at length evacuated, and the veſſels exhauſted in the night again; the ſame trachea being contracted by the coldneſs of the air, the other veſſels are eaſed and relaxed, and ſo diſpoſed to receive freſh food for the next day's digeſtion and excretion.

The juice being carried on to the germs or bud, is more concreted; and here having unfolded the leaves, which being expoſed to the alternate action of heat and cold, moiſt nights, and hot ſcorching days, are alternately expanded and contracted; and the more on account of their reticular texture.

By ſuch means the juice is farther altered and digeſted, as it is further yet in the petala, or leaves of the flowers, which tranſmit the juice, now brought to a further ſubtility to the ſtamina; theſe communicate it to the farina, or duſt in the apices, where having undergone a farther maturation, it is ſhed into the piſtil, and here having acquired its laſt perfection, gives riſe to a new fruit or plant.

Fig. 514. and the four following figures, repreſent the ſtructure of the woody fibres and lymphæducts both in the bark and wood.

Fig. 514. ſhews a ſingle veſſel in the bark of flax; and fig. 515. repreſents the ſame veſſel as ſeen in the microſcope, and greatly magnified; whence it appears to be

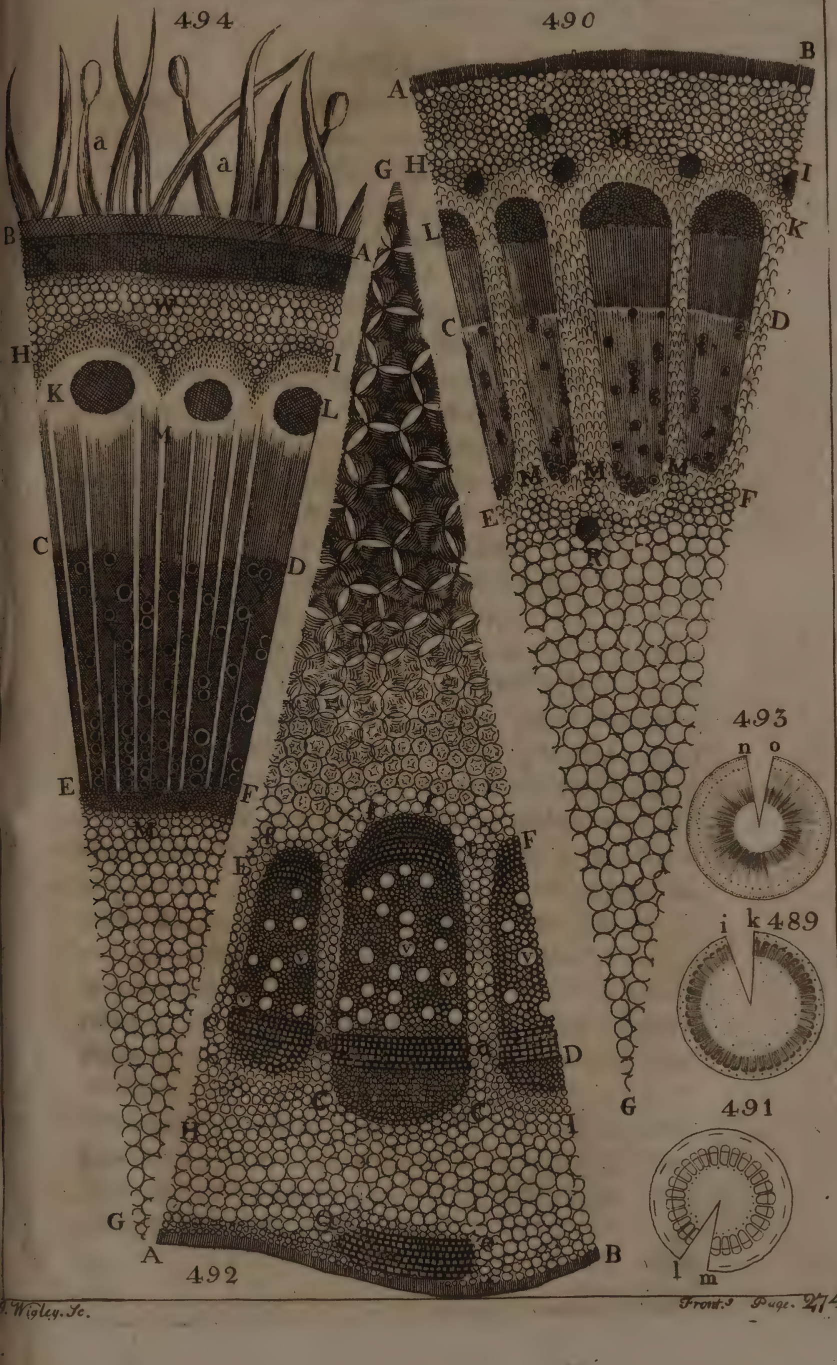
compoſed of a great number of other lignous fibres, with which alſo the parenchymous are intermixt.

Fig. 516. exhibits a parcel of the ſame veſſels in the wood of fir, greatly magnified; and at a, is ſeen the ſame piece of its natural ſize.

Fig. 517. A B ſhews a lymphæduct, and fig. 518. C, repreſents a lactiferous veſſel, both of which are ſurrounded with parenchymous bladders, and are greatly magnified.

Fig. 519. repreſents part of the ſtalk of ſumach, ſomewhat larger (and more magnified) than that of fig. 494. with ſeveral breaks in it, to ſhew the contexture both of the perpendicular and horizontal fibres; in which, as before, A B a a ſhews the hairy ſkin: A B C D the bark in which the fibres b b, c c, and d d, that hang down therefrom, are lymphæducts, one of which d d d, is compoſed of a great many other ſmaller fibres: H W I the parenchyma: D M C the common lymphæducts: K M L the milk veſſels compoſed of bladders: H I another ſort of lymphæducts arched over the milk veſſels: D C E F the wood, from which the fibres e f, that hang down, are ſome of them the old lymphæducts turned into wood; g h g h are two air veſſels in which the wreathing thereof is plainly ſeen, and from h to i is alſo ſeen part of the ſame veſſels unwreathed: O P is part of one of the inſertions compoſed of bladders, and thoſe bladders of threads: E F G are parts of the pith compoſed of thready or fibrous bladders.

Pl. 60



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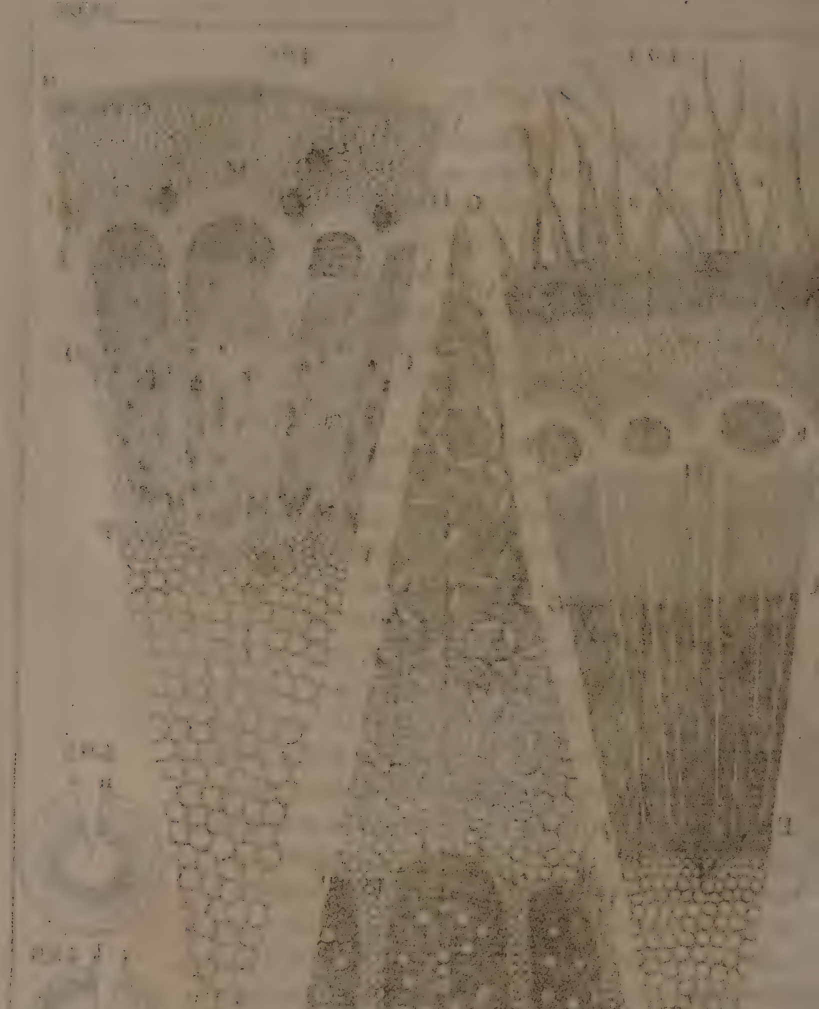


Of leaves.

THE leaves of trees or plants are full of innumerable ramifications, that convey the perſpirable juices to the pores for their diſcharge. The fibres of the leaf do not ſtand in even lines from the ſtalk, but always in an angular or circular poſture, and their vaſcular fibres or threads are 3, 5 or 7; the reaſon of their being in this poſition, is for the more erect growth and greater ſtrength of the leaf, as alſo for the ſecurity of its ſap. Another obſervable in the fibres of the leaf, is their orderly poſition, ſo as to take in an eighth part of a circle, as in mallows, in ſome a tenth, but in moſt a twelfth, as in holy-oak, or a ſixth, as in ſyringa.

The art of folding up the leaves before their eruption out of their germs, &c. is incomparable both for its elegancy and ſecurity, viz. in taking up (ſo as their forms will bear) the leaſt room; and in being ſo conveniently couched, as to be capable of receiving protection from the other parts, or of giving it to one another, e. gr. firſt there is the bow-lap, where the leaves are all laid ſomewhat convexly, one over another, but not plaited, but where the leaves are not ſo thick ſet as to ſtand in the bow-lap; there we have the plicature, or the flat lap, as in roſe-trees, &c. To theſe Dr. Grew adds their various foldings, which he calls by the names of the duplicature, multiplicature, the fore rowl, back rowl, and tre rowl or treble rowl.

To theſe curious foldings may be added another noble guard by the interpoſition of films, &c. of which Dr. Grew ſaith there are about ſix ways, viz. leaves, ſurfoyls, interfoyls, ſtaks, heads, and mantlings.

The various methods which nature takes to preſerve the leaves from the injuries both of the ground and weather are, viz. the young buds of ammi, at their firſt eruption from the ground, are couched, as fern is rowled inward; each bud, againſt the brace of the ſtalk of the foregoing leaves, and moſt exactly incloſed in the membranes thence produced. Nature hath generally provided them with another protection, where the ſtalks of the leaves are ſo long that they cannot lap over each other, the bottoms of the ſtalks are expanded into broad membranes, as in crows-foot, doves-foot, clover, cranſhill, ſtrawberry, harrow, &c. and ſometimes inſtead of two ſkins lapped over each other, one entire ſkin is produced from the ſtalk, in which, as within a ſecundine, the bud is ſafely lodged, which it gradually breaks open in its growth.

It is alſo obſervable in dock, ſorrel, biſtort, and all other plants of this ſort, with this difference, that every veil or ſecundine is not here produced from the ſtalk of the leaf; whereas in the former every bud hath one to itſelf in theſe plants, every leſſer leaf, together with its own proper veil, is always incloſed with the next greater leaf in another common to them both, and both theſe with the next in another, and ſo on to the greateſt. The orchis, and other plants of this ſort, have a double ſheath over all. The buds of ſome herbs as plantain, having no hairs growing over them, are covered with hairy thrums, and the nettle hath baſtard-leaves or interfoyls between leaf and leaf, for the preſervation of its ſtings.

Another ſort of protection is ſeen in white archangel, and other plants of a like ſhape. In which the greater leaves do alſo incloſe the leſſer, by a double fore curl at the bottom of every two great leaves, which embraces the little under bud, and ſo keeps it clean and warm.

The leaves of onions are all pipes one within another, having a ſmall aperture about the middle common to all of them, even the moſt minute ones in the center.

As the buds of common ſumach are exceeding tender, nature appears in a peculiar manner ſolicitous for their preſervation, being lodged within the body of the ſtalk, as entirely as a kernel is within an apple; from whence it is that the baſis of every ſtalk is extremely ſwelled.

There are alſo globular excreſcencies, ſpots, hairs, thorns, and prickles.

Globulets are ſeen upon orach, but more plainly upon bonus henricus, in theſe growing almoſt upon the whole plant, and being very large, are by moſt people taken notice of; but the microſcope hath diſcovered to us that they are the natural and conſtant offspring of very many other plants, they are of two kinds tranſparent, as upon the leaves of hyſop, mint, baume, &c. white on germander, ſage, &c. Sometimes they appear like a fine powder upon the leaf, theſe were firſt white and tranſparent as in bear's ear. If this be licked of, it will afford the taſte of the eſſential content of the plant. They frequently grow on both ſides the leaf, yet ſometimes, as in ground-ivy, chiefly on the back ſide thereof, and in many plants where the elder-leaves have none, on the young buds they are very numerous, as in corin-tree, ſorrel, and others.

Spots are obſervable in St. John's-wort, rue, ground-ivy, pimpernel or anagallis, &c. when held up againſt the light.

Thorns are lignous and cortical, the firſt are ſuch as thoſe of hawthorn, ſomewhat like theſe are the ſpinets or

thorny

thorny prickles, upon the edges and tops of divers leaves, as barberry, holly, thiſtle, furz, &c.

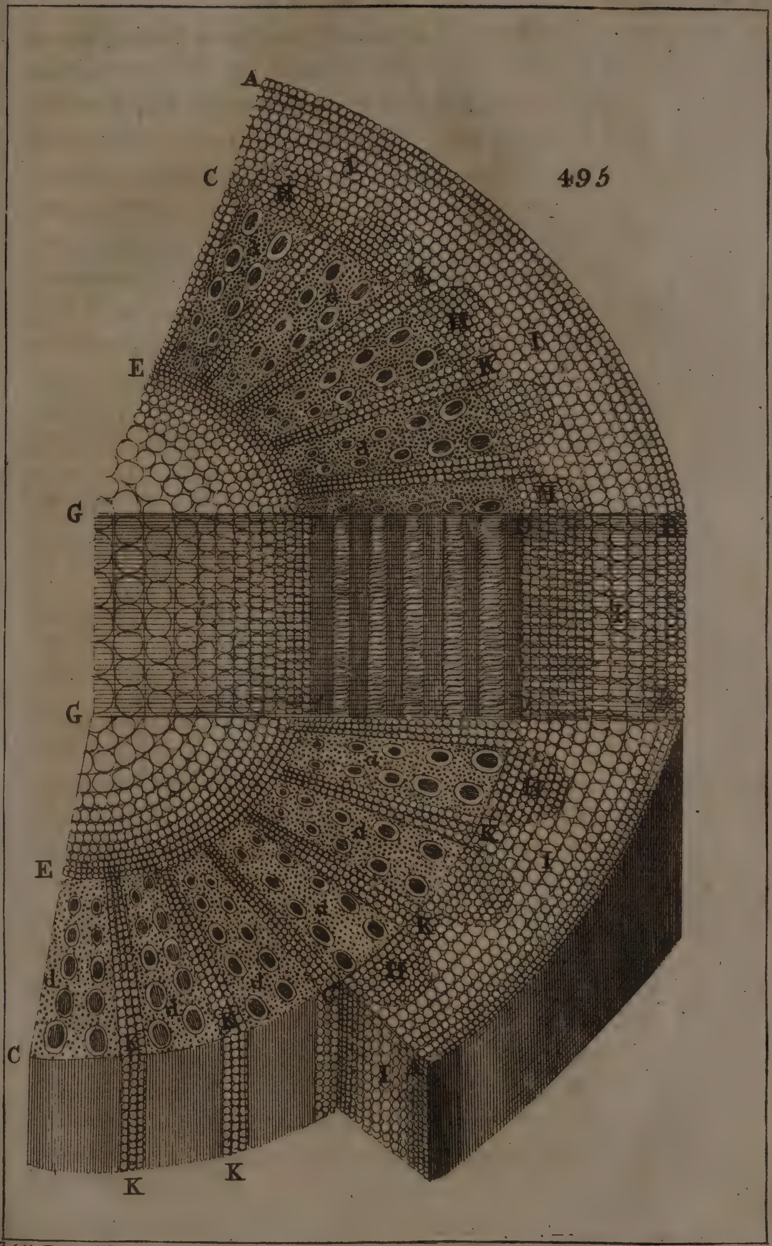
Cortical thorns are ſuch as thoſe of the raſberry-buſh, being not, unleſs in an inviſible proportion, propagated from the lignous body. They are of uſe not only for the protection of the bud, but alſo for the ſupport of the plant.

The uſe of hairs on leaves are to preſerve young buds, not only from the cold air, but alſo from too much wet, which if it were contiguous would often rot and dry them. But being made to ſtand off in drops, at the ends of the hair, does not hurt but refreſh them. Thus we ſee by the aſſiſtance of the microſcope, that nature oftentimes makes the meaneſt things ſubſervient to the beſt ends.

Of the parts and texture of the leaf.

THE firſt part which here preſents itſelf is the ſkin, a ſmall bit of which being ſtripped off the leaf, and laid upon the object carrying glaſs R, of fig. 2. or held between the nippers, and then placed before the microſcope, will appear to conſiſt of parenchymous and lignous fibres, all very curiouſly and admirably interwoven, as in flag, tulip, &c.

From hence it is eaſy to conceive, that the ſkins of all plants (as well as thoſe of animals) are perſpirable between the ſeveral fibres of which they conſiſt, formed into ſeveral orifices, either for the better avolation of ſuperfluous ſap, or the admiſſion of air; theſe orifices are not in all leaves alike, but varied in bigneſs, number, ſhape, and poſition, and are the cauſe of the gloſs on the upper-ſide of the leaves, the backſide having none of them.



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Next the ſkin lies the pulpy part of the leaf, called the parenchyma, being compoſed of an incomparable number of little cylindrical fibres, which are in moſt leaves wound up into minute bladders, but generally more viſible in the ſtalk than in the body of the leaf. In ſome leaves, as in borage, fig. 520. the greater bladders are made up of leſſer ones, and in ſome others theſe parenchymous fibres are all drawn up cloſe together.

The pithy part in the ſtalk, and almoſt up to the top of the chief fibre, in many leaves is tubular, even whilſt they are yet young and ſappy, as in ſweet cervil, hemlock, endive, cichory, lampſana, dandelion, burdock, daize, ſcorzonera, and others, and ſometimes the ſaid pithy part is opened into ſeveral pithy pipes; the fibres alſo of the leaf, which is viſible to the naked eye, are compoſed of ſap and air veſſels. Their poſition is various and regular, not only in the body of the leaf, but likewiſe in the ſtalk, as in the ſtalk of a mallow-leaf, fig. 521. they ſtand in ſix oblong parcels of equal ſize, and in a circle near the circumference. In dandelion, wild clary, and in borage, fig. 522. they ſtand in five parcels.

In the body of the leaf, beſides the poſitions of the fibrous ſtrings, there is one in particular which runs round the edge of the leaf in all plants; but can hardly be well diſcovered without ſtripping off the ſkin of the leaf. The continuation of the veſſels ſeem to be ramified, and ſeem alſo to be inoſculated.

Theſe tracheæ or air veſſels are viſible, and appear very pretty in the leaf of ſcabious, or the vine, by pulling aſunder ſome of its principal ribs or great fibres; between which may be ſeen the ſpiral air veſſels (like threads of a cob-web) a little uncoyled, as repreſented by fig. 523. which ſhews a piece of a vine-leaf, wherein theſe veſſels were drawn out and a little magnified, and at a the ſpiral circumvolutions are repreſented as they appeared in the microſcope when greatly magnified, and as they ſtand intire within the wood; and at b is ſeen one a little ſtretched.

Mr. Leeuwenhoek tore a leaf of box to pieces, called palma cereris, that he might the better examine it, and computed one ſide thereof to contain 172090 pores, and as the other ſide muſt conſequently have the ſame number, the whole pores in a box-leaf will be 344180.

Of roſemary-leaves.

FIG. 524. repreſents a ſmall part of the underſide of a roſemary-leaf [y], whereof A B ſhews part of the upper ſide which was doubled over, and conſiſted of a ſmooth ſhining ſubſtance, but its under-ſide appeared in the microſcope like a thicket of buſhes, amongſt which were a great number of round balls, exactly globular, and afford a very agreeable proſpect.

The back-ſide of a roſe-tree leaf, but eſpecially of a ſweet briar leaf, looks diapered with ſilver.

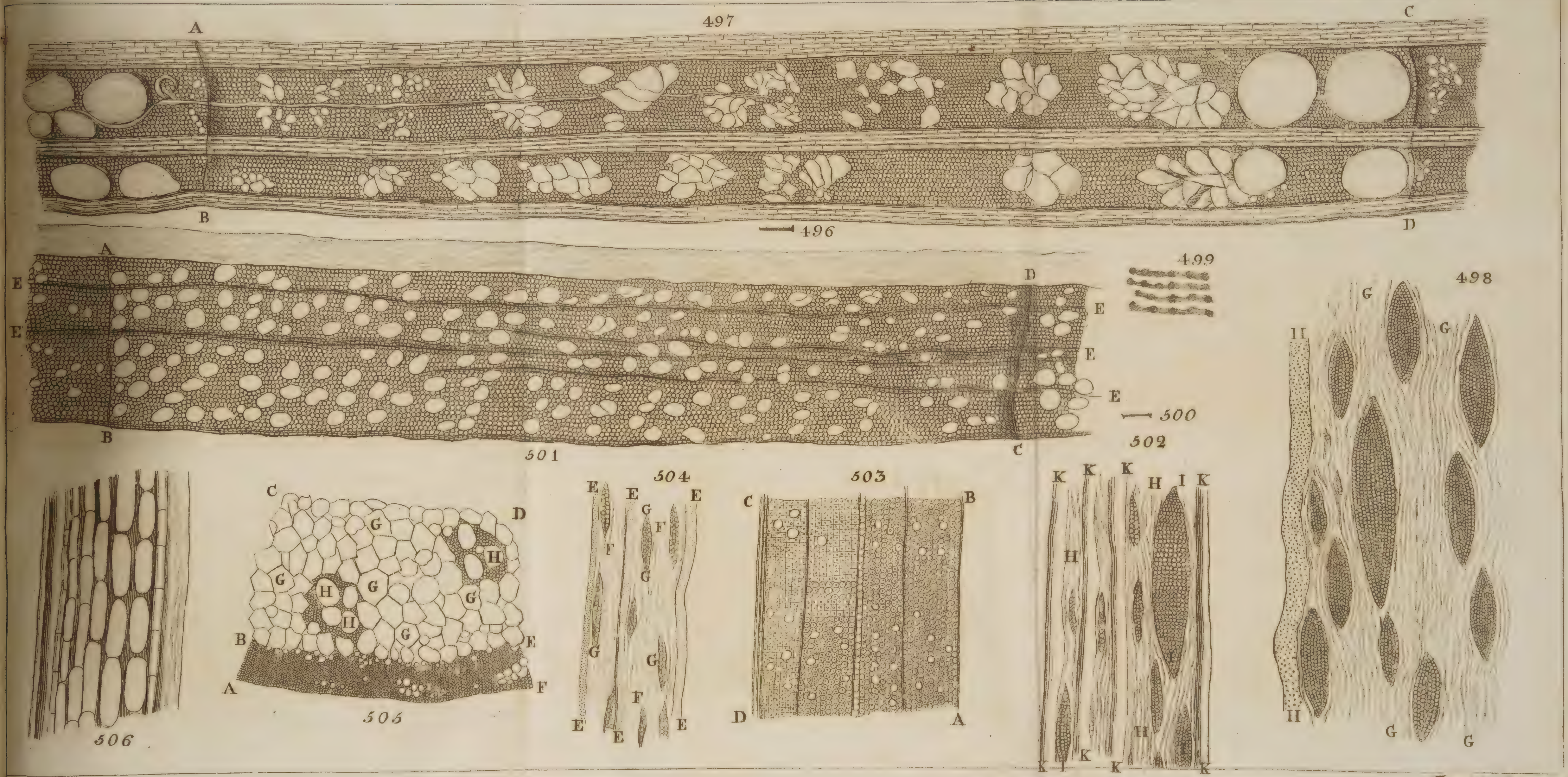
The back of the leaf of Engliſh Mercury [z] looks as if rough caſt with ſilver, and all the ribs ſet round with white tranſparent balls.

A leaf of rue looks full of holes like an honey-comb.

A ſage-leaf is taſſeled with white ſilver thrums, and one or two cryſtal beads, or pendants, faſtened to every knot.

[y] Hook's Mic. p. 142.

[z] Power's Mic. Obſ. p. 50.



J. Wigley. Sc.

Front.g Page. 230.

Of ſtinging-nettles.

A Nettle is a plant known almoſt to every body, there being very few but what have felt as well as ſeen it; but how the pain is ſo ſuddenly created, and by what means continued, we muſt have recourſe to the microſcope for our information, and that will, if almoſt any part of the plant be looked on, ſhew us the whole ſurface thereof to be very thick ſet with ſharp points, that penetrate the ſkin when touched, and occaſion pain, heat, and ſwelling; they are repreſented in a ſmall part of the leaf as they appear in the microſcope, by fig. 525. at A B, conſiſting of a rigid hollow body tapering from B, till it terminate in the moſt acute point imaginable, being exceedingly clear and tranſparent. At the bottom of this cavity lies a minute bag B, containing a limpid liquor [a], which upon the leaſt touch of the prickle, is ſquirted through the little orifice, and if it enters the ſkin, produces the before-mentioned miſchiefs by the pungency of its ſalts. C D ſhews one of the chief fibres of the leaf, from whence the ſtings proceed.

The other parts of the leaf or ſurface of the nettle have very little conſiderable, but what is common to moſt plants, as the ruggedneſs, indenting, and hairineſs, and other roughneſſes of the ſurface, on the outſide of the plant.

Of cowage, or cowitch.

THERE is a certain down of a plant, brought from the Eaſt-Indies, which grows on a kind of hairy kidney bean [b]. The pods about three inches long, reſemble a French bean, and are covered with this down or hair, which is very ſtiff for its bigneſs, and cauſes pain, and inflammations, if rubbed on any part; and when viewed by the microſcope, this down appears to be a multitude of pointed thorns exquiſitely ſharp.

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[a] Hook's Mic. p. 143.

[b] Ibid. p. 146.

Of the texture of the leaves of ſea-weeds.

IT is a plant which grows upon the rocks under water, increaſing and ſpreading itſelf into a great tuft, which is not only handſomely branched into ſeveral leaves, but its whole ſurface is covered over with a curious kind of carved work [c], conſiſting of a multitude of very ſmall holes, ranged in the neateſt and moſt delicate order; a ſmall piece thereof is repreſented as it appeared in the microſcope, at fig. 526.

Of flowers.

A Flower is that part of a plant which contains the organs of generation, or the parts neceſſary for the propagation of the kind.

It is a natural production, which precedes the fruit, and yields the grain or ſeed.

Their ſtructure is ſomewhat various, though the generality, according to Dr. Grew, have theſe three parts entire, the empalement, the foliation, and the attire.

Mr. Ray reckons, that every perfect flower has the petala, ſtamina, apices, and ſtylus, or piſtil; ſuch as want any of theſe he deems imperfect flowers.

In moſt plants there is a perianthium, calyx, or flower cup, of a ſtronger conſiſtence than the flower itſelf, and deſigned to ſtrengthen and preſerve it.

Flowers,

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[c] Hook's Mic. p. 140.

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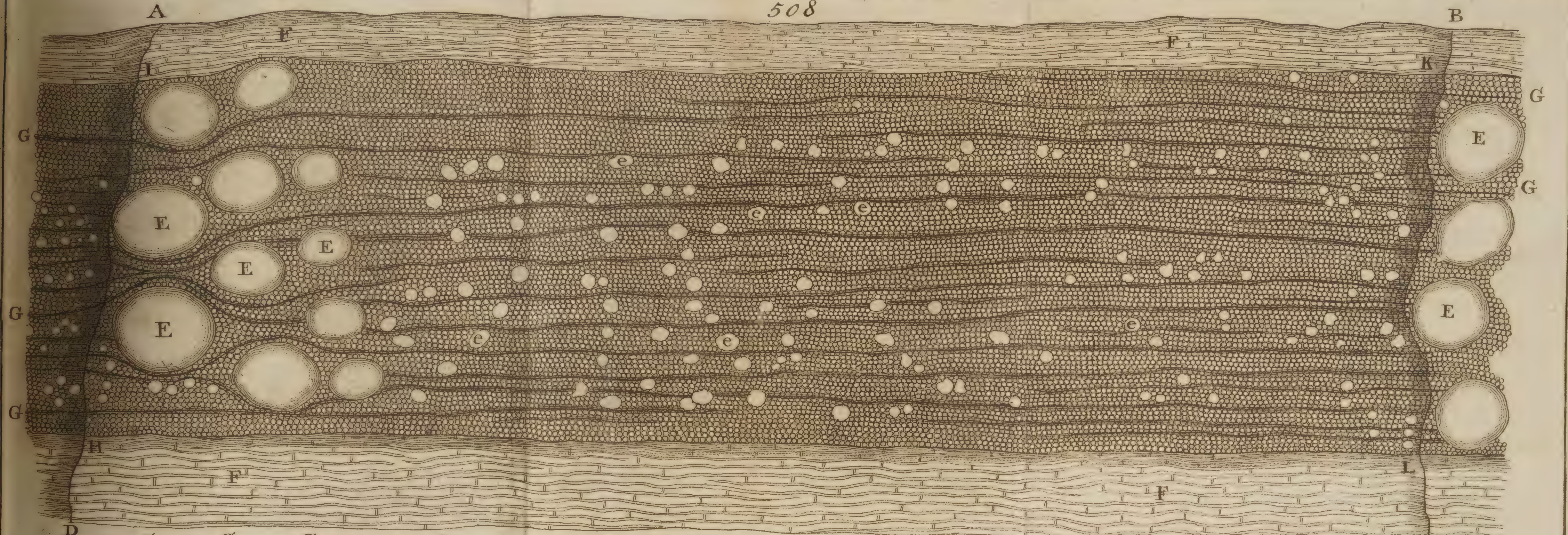

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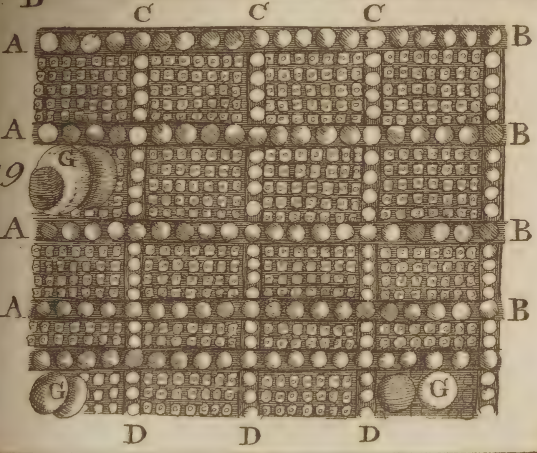

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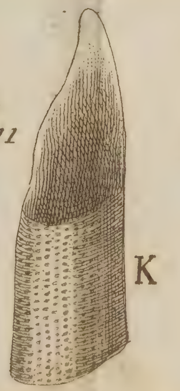

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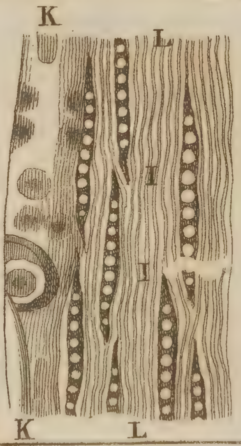

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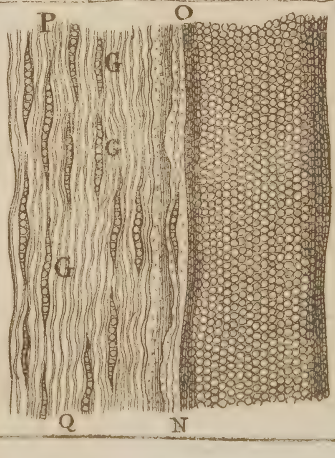

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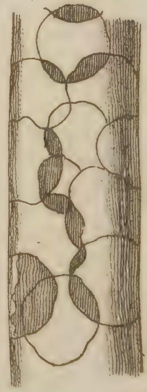

Bowles sc.

Flowers, whoſe petala are ſtrong (as tulips), have no calyx; carnations, whoſe petala are long and ſlender, have an empalement of one piece; and others as knapweeds, have it conſiſting in ſeveral pieces, and in divers rounds, and all with a counterchangeable reſpect to each other, for the greater ſtrength and ſecurity of themſelves and the petala, &c. they include.

The next is the foliation, as Dr. Grew, the petala, or folia, as Mr. Ray, and others; in theſe, not only the admirable beauty, and luxuriant colours are obſervable, but alſo their curious foldings, in the calx before their expanſion, of which Dr. Grew hath theſe varieties, viz. the cloſe couch, as in roſes, and ſeveral other double flowers; the concave-couch, as in blataria; flora albo, the ſingle plait, as in peaſe-bloſſoms; the double plait, as in blew-bottles, &c. the couch and plait together, as in marigolds, daizes, &c. the rowl, as in lady bower; the ſpire, as in mallows; and laſtly, the plait and ſpire together, as in convolvulus doronici folio.

As to the ſtamina with their apices and ſtylus (called the attire by Dr. Grew) they are admirable, whether we conſider their colours, or their make, but eſpecially their uſe, if it be as Dr. Grew, Mr. Ray, and others imagine, namely, as a male ſperm, to impregnate and fructify the ſeed; which opinion is corroborated by the ingenious obſervations of Mr. Samuel Moreland, viz.

All flowers, in general, or at leaſt the greateſt part of them, are furniſhed with chives, tops, and piſtils.

The farina, or fine mealy powder, which is at its proper ſeaſon ſhed out of thoſe thecæ or apices; ſeminiformes which grow at the top of the ſtamina, do in ſome meaſure perform the office of a ſemen maſculinum, by dropping upon the outſide of the uterus or vaſculum ſeminale, and impregnate the included ſeed, &c. But Dr. Moreland

land was of opinion, that the ſeeds which come up in their proper involucra, are at firſt like the unimpregnated ova of animals; that this farina is a congeries of ſeminal plants [d], one of which muſt be conveyed into every ovum, before it can become prolifick. That the ſtylus, as Mr. Ray, or the upper part of the piſtulum, as Mr. Tournefort calls it, is a tube deſigned to convey theſe ſeminal plants into their neſt in the ova; and that there is ſuch a vaſt proviſion made thereof, becauſe of the odds there are, whether one of ſo many ſhall ever find its way into, and through ſo narrow a conveyance.

For in the corona imperialis, where the uterus or vaſculum ſeminale of the plant ſtands upon the centre of the flower, from the top of which ſtands the ſtylus; the vaſculum ſeminale, and ſtylus together, repreſenting a piſtillum; round this are planted ſix ſtamina; upon the extremities of each of theſe are apices, ſo artfully fixed, that they turn every way with the leaſt blaſt of wind, being in height almoſt exactly equal to the ſtylus, about which they play, and which in this plant is manifeſtly open at top; it is hollow all the way, and upon the top of the ſtylus there is a ſort of tuft, conſiſting of pinguid villi, ſuppoſed to be placed there to catch and detain the farina, as it flies out of its thecæ; and that the rain either waſhes it, or the wind ſhakes it down the tube, till it reaches the vaſculum ſeminale.

In the caprifolium or honey-ſuckle, there riſes a ſtylus from the rudiments of a berry, into which it is inſerted, to the top of the monopetalous flower; from the middle of which flower are ſent forth ſeveral ſtamina, that ſhed their farina off the caſes, upon the orifice of the ſtylus, which in this plant is villous or tufted, upon the ſame account as the former is.

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[d] Phil. Tranſ. No. 287.

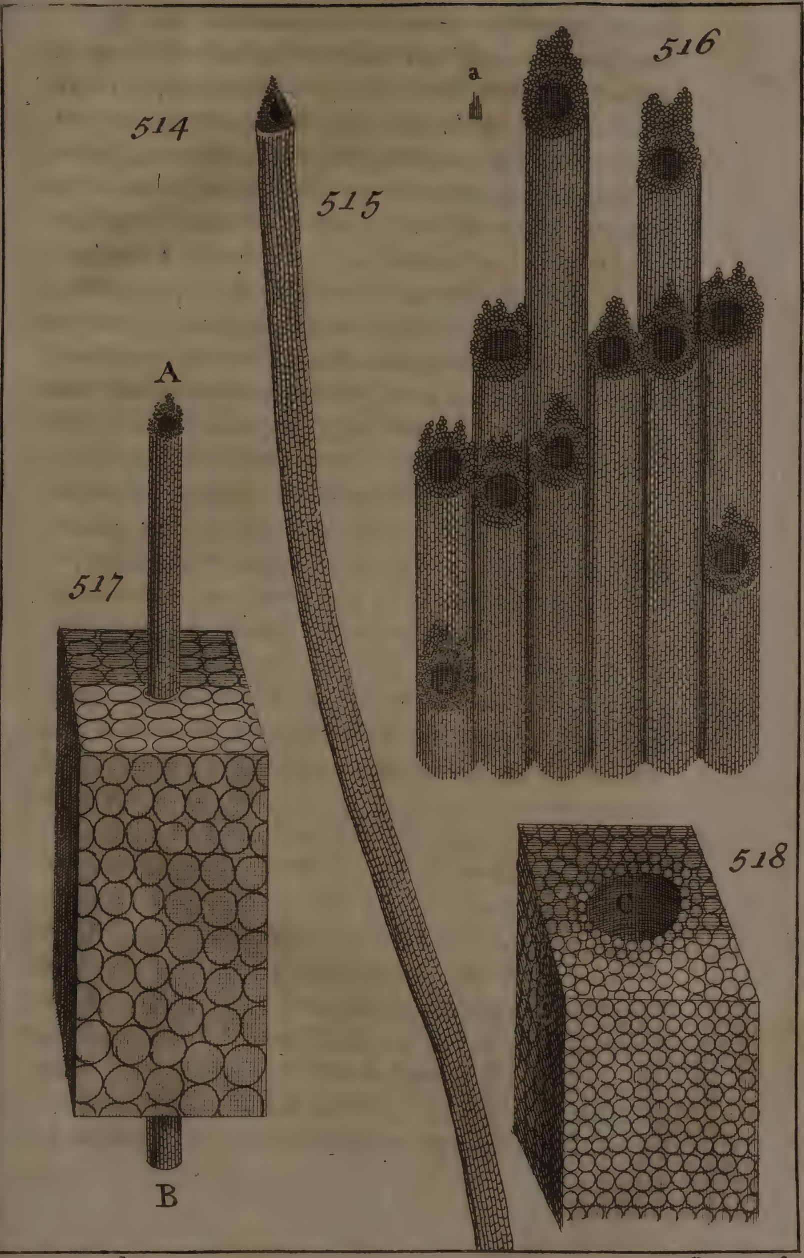
In allium or common garlick, there ariſes a tri-coccous uterus, or ſeed-veſſel, in the center of which is inſerted a ſhort ſtylus, not reaching ſo high as the apices, which thus overtopping it, have the opportunity of ſhedding their globules the more eaſily into its orifice; for which reaſon there is no tuft on this as on the former, to inſure its entrance, that being provided for by its ſituation juſt under them.

From whence we conclude, that where a fine powder is curiouſly prepared, carefully repoſited, and ſhed abroad at a peculiar ſeaſon, where there is a tube planted in ſuch a manner, as to be fit to receive it, and ſuch care in diſpoſing this tube, that where it does not lie directly under the caſes that ſhed the powder, it hath a peculiar apparatus at the extremity to inſure its entrance, ſo that nothing can be more genuinely deduced from any premiſes, than it may from theſe, that this powder, or ſome of it, was deſigned to enter this tube; if theſe ſtamina had been only excretory ducts, to ſeparate the groſſer parts, and leave the juice deſigned for the nouriſhment of the ſeed the more reſerved, what need was there to lodge theſe fæces in ſuch curious repoſitories? they would have been conveyed any where, rather than where there was ſo much danger of their dropping into the ſeed-veſſel again, as they are here. Again, the tube, over the mouth of which they are ſhed, and into which they enter, leads always directly into the ſeed-veſſel; to which may be added, that the tube always begins to die, when theſe thecæ are emptied of their contents; if they laſt any longer, it is only whilſt the globules which enter at their orifice, may be ſuppoſed to have finiſhed their paſſage; nor can we expect a more convincing proof of theſe tubes being deſigned to convey theſe globules, than that they wither when there are no more globules to be conveyed.

In leguminous plants, if the petala of the flower be carefully taken off, the pod or ſiliqua may be diſcovered, cloſely covered with an involving membrane, which about the top, ſeparates into ſeveral ſtamina, each being fraught with its quantity of farina; and theſe ſtamina bound cloſe upon the bruſh, which is obſervable at the extremity of that tube, which here alſo leads to the pod; it does not indeed ſtand upright, but bent ſo as to make almoſt a right angle with it: in roſes there ſtands a column conſiſting of ſeveral tubes, clung cloſely together, though eaſily ſeparable, each leading to its peculiar cell, having the ſtamina in great numbers planted all round. In tithymalus or ſpurge, there ariſes a tricoccous veſſel, that, whilſt it is ſmall and ſo not eaſily diſcernable, lies at the bottom, till it is impregnated; but afterwards it grows up and ſtands ſo high upon a tall pedicle of its own, as would incline one to think, that there was to be no communication between this and the apices, which he ſees dying below. In ſtrawberries and raſberries, the hairs which grow upon the ripe fruit are ſo many tubes, each leading to its particular ſeed; and therefore we may obſerve, that in the firſt opening of the flower there ſtands a ring of ſtamina within the petala, and the whole inward area appears like a little wood of theſe hairs or pulp, which when they have received and conveyed their globules, the ſeed ſwells and riſes in a carnous pulp.

Fig. 527. repreſents a yellow lilly. A, the top of the piſtil or tube, at which the ſeminal plants are ſuppoſed to enter, and through which they are conveyed to the unimpregnated ſeeds in the ſeed-veſſels; b b the apices ſemini-formes, which when open, ſhed that powder which enters the tube at A; C the place of the ſeed-veſſel at the bottom of the tube, the tube and veſſel itſelf being concealed under the leaf in this figure.

Pl. 64.



Front.⁹ Pag 286.

Bowles ſc.

Fig. 528. repreſents the ſiliqua in a flower of a pea kind, E the tube which ariſes from the ſiliqua, and conveys the plants thereto; F the membraneous coat which involves the ſiliqua laid open: g g g g the apices, which before the membraneous tegument is laid open, appear to riſe from its edges, and by the petala of the flower are kept cloſe upon the orifice of the tube, that they may conveniently ſhed their farina into it.

Hence we learn from the general ſtructure of the flowers of plants, though diverſified infinite ways, that ſome have no ſenſible piſtil, others no ſtamina, others have ſtamina without any apices; and what exceeds all the reſt, ſome plants have no flowers.

Mr. Bradley obſerves, that at the bottom of the piſtil of the lilly, there is a veſſel which he calls the uterus, or womb, wherein are three ovaries filled with little eggs, or rudiments of ſeed, which, ſays he, always decay and come to nothing, unleſs impregnated by the farina of the ſame plant, or ſome other of the ſame kind.

It is this farina or duſt falling out of the apices on the piſtil, fœcundifies the grain or fruit incloſed therein; and hence they call it the farina fecundans. Thus the farina ſhould be the male part of the plant, and the piſtil the female.

The fruit is uſually at the baſis of the piſtil, ſo that when the piſtil falls with the reſt of the flower, the fruit appears in its ſtead. The piſtil is frequently the fruit itſelf, but ſtill they have both the ſame ſituation in the center of the flower, whoſe leaves diſpoſed around the little embrio, only ſeem deſtined to prepare a fine juice in their little veſſels for its ſupport. Mr. Bradley imagines their uſe to be only to defend the flower.

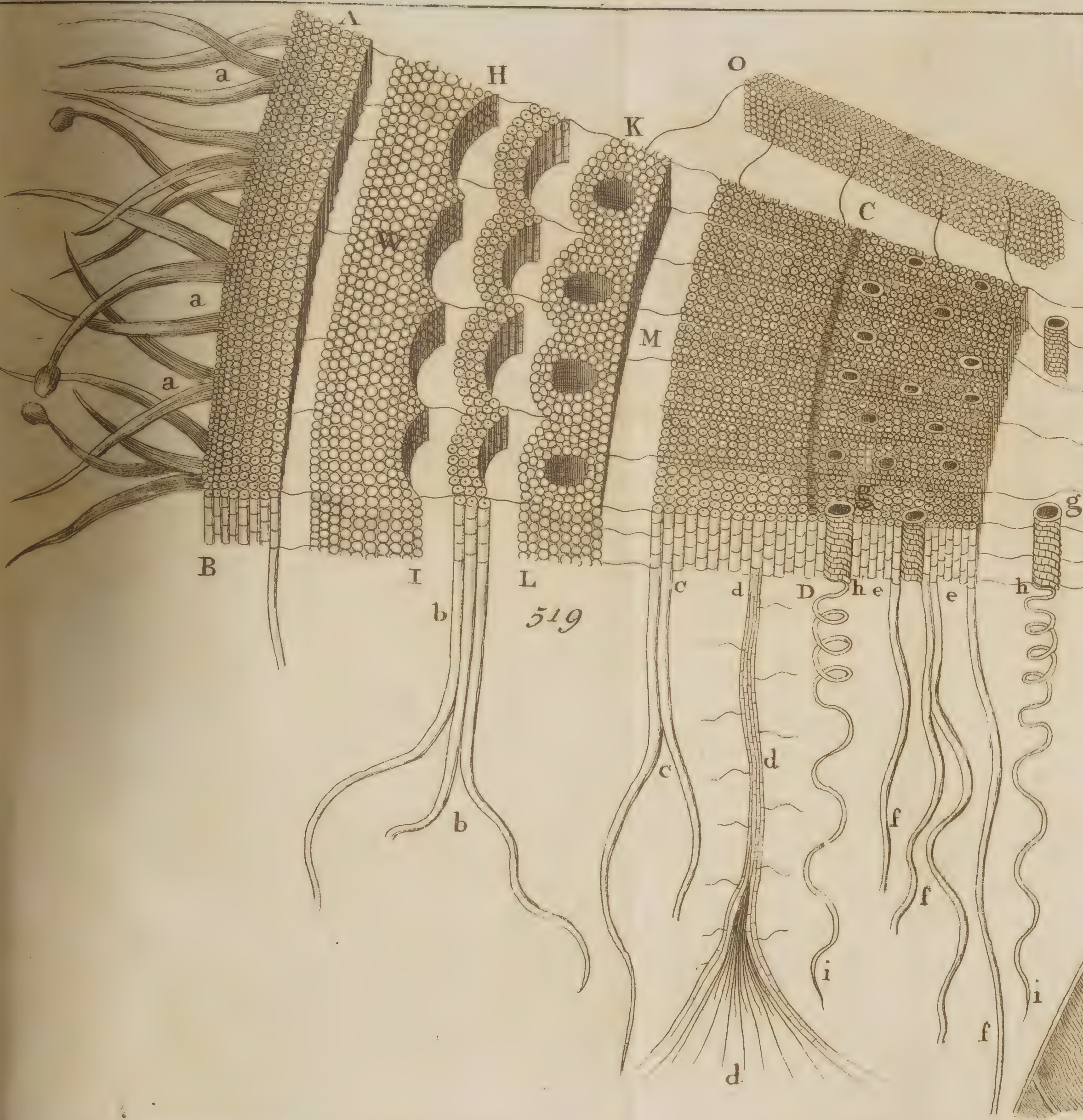
The diſpoſition of the piſtil, and the apices about it, is always ſuch, as that the farina may fall on its orifice;

it is uſually lower than the apices; and when we obſerve it to be grown higher, we may conjecture the fruit has begun to form itſelf, and has no further occaſion for the male duſt. Alſo, as ſoon as the work of generation is over, the male parts, together with the leaves, fall off, and the tube leading to the uterus begins to ſhrink. Nor muſt it be omitted, that the top of the piſtil is always either covered with a ſort of velvet tunicle, or emits a gummy liquor, the better to catch the duſt of the apices. In flowers that turn down, as in the acanthus, cyclamen, and the imperial crown, the piſtil is much longer than the ſtamina, that the duſt may fall from their apices in ſufficient quantity thereon.

This ſyſtem favours much of that admirable uniformity found in the works of nature, and carries with it all the ſeeming characteriſticks of truth. Mr. Geoffroy ſays, that the plant is rendered barren, and the fruits become abortive, by cutting off the piſtils before the duſt could impregnate them, which is ſince confirmed by other experiments of Mr. Bradley.

In many kinds of plants, as willow, oak, pine, cypreſs, mulberry-tree, &c. the flowers are ſterile, and ſeparate from the fruit; but then they have their ſtamina and apices, which may eaſily impregnate the fruits, which are not far off.

There is ſome difficulty in reconciling this ſyſtem to a ſpecies of plants, which bear flowers without fruits, and another ſpecies of the ſame kind and name, which bear fruits without flowers; hence diſtinguiſhed into male and female; of which kind are the palm-tree, poplar, hemp, hops, &c. for how ſhould the farina of the male here come to impregnate the ſeed of the female. Mr. Tournefort imagines, that the fine down always found on the fruit of theſe plants, may ſerve inſtead of flowers, and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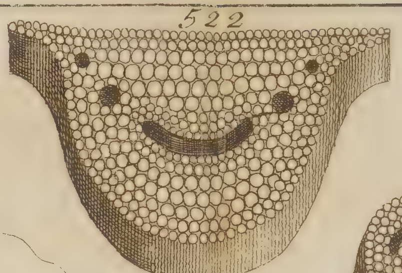
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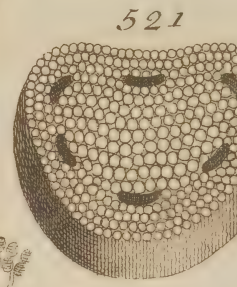
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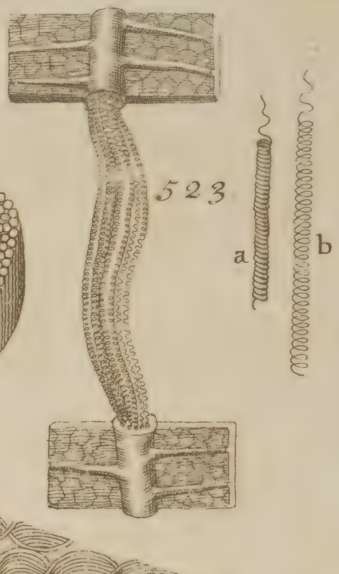
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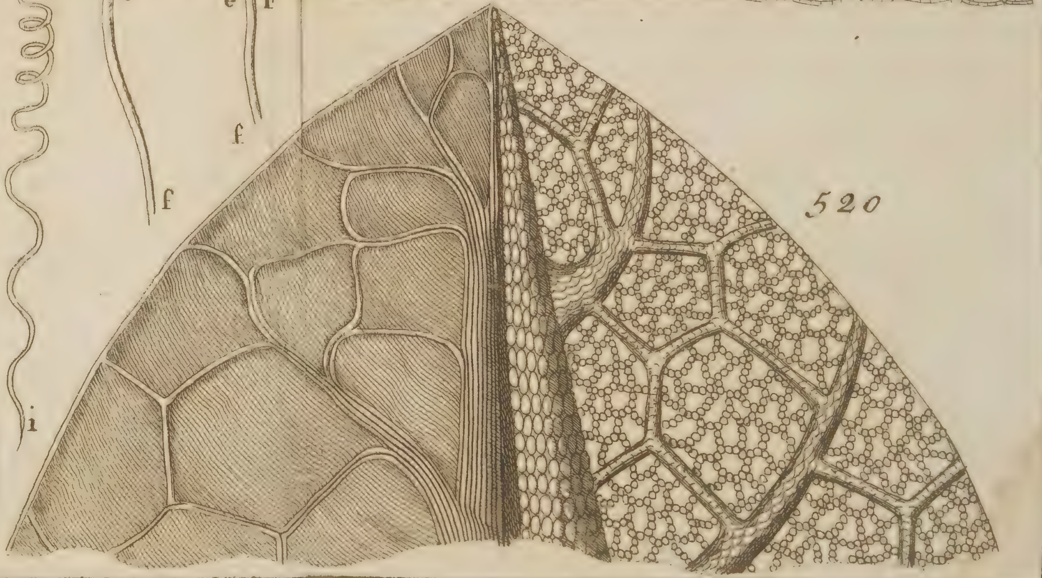
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Bowles sc.

and do the office of impregnation; but Mr. Geoffroy rather takes it, that the wind doing the office of a vehicle, brings the farina of the males to the females.

For the manner wherein the farina fecundifies, Mr. Geoffroy advances two opinions, 1. That the farina being always found of a ſulphurous compoſition, and full of ſubtile penetrating parts, falling on the piſtil of the flowers, there reſolves, and the ſubtileſt of its parts penetrating the ſubſtance of the piſtil and young fruit, excite a fermentation ſufficient to open and unfold the young plant, contained in the embrio of the ſeed; in this hypotheſis the ſeed is ſuppoſed to contain the plant in miniature, only wanting a proper juice to unfold its parts and make them grow.

The ſecond opinion is, that the farina of the flower is the firſt germ, or bud of the new plant, and needs nothing to unfold it, and enable it to grow, but the juice it finds prepared in the embrio's of the ſeed.

The reader will here obſerve, that theſe two theories of vegetable generation, bear a ſtrict analogy to thoſe of animal generation, viz. either that the young animal is in the ſemen maſculinum, and only needs the juice of the matrix to cheriſh and bring it forth, or that the animal is contained in the female ovum, and needs only the male ſeed to excite a fermentation.

Mr. Geoffroy takes the proper ſeed to be in the farina, becauſe the beſt microſcopes do not diſcover the leaſt appearance of any bud in the little embrio's of the grains, when examined before the apices have ſhed their duſt.

In leguminous plants, if the leaves and ſtamina be removed, and the piſtil, or that part which becomes the pod, be viewed with the microſcope, ere yet the flower be opened, the little green tranſparent veſiculæ, which are to become the grains, will appear in their natural

order,

order, but ſtill ſhewing nothing elſe but the mere coat or ſkin of the grain.

If the obſervation with the microſcope be continued for ſeveral days ſucceſſively, in other flowers as they advance, the veſicula will be found to ſwell, and by degrees to become replete with a limpid liquor; wherein when the farina comes to be ſhed, and the leaves of the flower to fall, we obſerve a little greeniſh ſpeck, or globule, floating about at large. At firſt there is no appearance of organization in this little body; but in time, as it grows, we begin to diſtinguiſh two little leaves like two horns. The liquor inſenſibly diminiſhes as the little body grows, till at length the grain becomes quite opake; when upon opening it, we find its cavity filled with a young plant in miniature, conſiſting of a plumula, radicle, and lobes.

The tops or apices ſometimes ſtand erect above their chives or ſtamina, as thoſe in lark-heel, but generally hang a little down by the middle like a kidney bean, as in mallows; they have for the moſt part a double cleft, though it is in ſome ſingle, from which they diſburſe their powders which ſtart out, and ſtands upon the lips of the cleft, as at fig. 529. which repreſents one of the apices of the flower of St. John's wort magnified.

The particles of theſe powders although like meal or duſt, yet if viewed through a microſcope, they have all of them very curious and regular forms. In dog's-mercury and borage they are extreamly ſmall, but in mallows fairly viſible to the naked eye. In ſome flowers theſe powders are yellow, as in dog's-mercury, goat's rue, &c. and in ſome of other colours, but in moſt they are white; thoſe of yellow henbane are very elegant, being to the naked eye as white as ſnow, and in the microſcope as tranſparent as cryſtal.

The tops or apices which contain the farina, are for the moſt part either white or yellow, ſometimes blue, but never red. Whatever colours the flowers be of, they differ in poſition, ſometimes ſtanding double upon one chive, as in toad-flax, ſnap-dragon, &c. In ſome they are faſtned to their ſtamina at their middle, as in Spaniſh broom, hyſſop, ſcabeous, behen, &c. in ſome erect, as in clematis, auſtriaca, ladies looking-glaſs, rape crow-foot, &c. coded arſmat hath no chives, but ſtand upon a large baſe.

Their number are alſo different, in great celandine, roſe, rape-crow-foot they are numerous; in great plantain, and ſome other herbs, much more conſpicuous than the foliature itſelf. In germander chickweed, they are always two, and no more; in ſome they follow the number of the leaves, eſpecially in the number five; as in blattaria, black henbane, &c. In ſtichwort and lychnis ſylveſtris they are ten, juſt double to the number of leaves.

Their ſhape is different, and always very elegant, with great variety. In borage, like the point of a ſpear; in blattaria, like an horſe-ſhoe; in clematis like a ſpatula, wherewith Apothecaries make their mixtures: in mallow like a head-roll; in hyſop they have one cleft before, in blattaria one round about; in water betony one at the top; in ſcabious they have a double cleft, one on each ſide.

In colocynthis the farina is not contained in ſeveral thæcæ or apices ſtanding upon chives, but is all of one entire part, like a thick column in the midſt of the flower, having ſeveral little ridges or furrows winding from the top to the bottom round about, in the middle of each of which runs a line, where the ſkin, after ſome time, opens into two lips, and preſents the globular particles contained in the hollow of every ridge.

But where the ſeeds are contained in the apices, a ſtilus or little column ſtands upon the top of the true ſeed-caſe, which is alſo regularly and variouſly figured. In bindweed it hath a round head like that of a great pin. In the common bell, St. Johnwort, &c. it is divided into three parts. In gerarium into five; in aſarum into ſix; ſometimes the head is ſmooth, and in others it is beſet with little thorns, as in hyoſcyamus.

The piſtil is a little upright part in the middle of the calx, or the leaves of flowers, called alſo the ſtyle.

It is an eſſential part of a flower, and the principal female organ of generation, it being in this that the ſeeds or young plants are formed. It ariſes from the pedicle of the flower, or the center of the calx, and at length becomes the young fruit, which is ſometimes hid in the calx, and ſometimes quite out.

Its figure is very different in different flowers; in ſome it is a little ſtalk, which enlarges at the two ends, in others a mere ſtamen or thread, ſometimes it is round, ſometimes ſquare, triangular, oval, &c.

Almoſt all piſtils are furniſhed at top, either with fine hairs, or little filaments diſpoſed in plumes, or are beſet with little veſicles full of a glutinous juice.

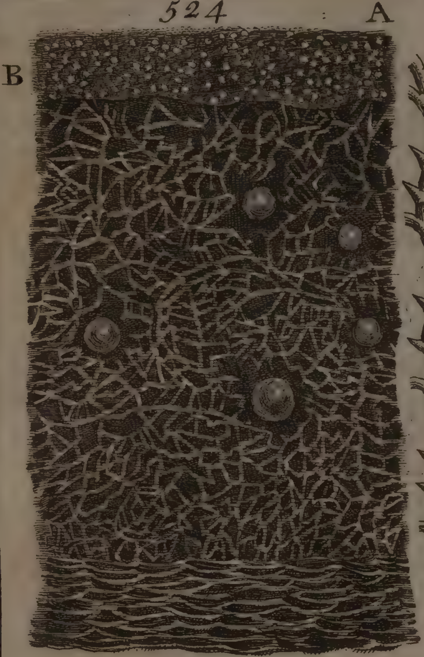
Some flowers have ſeveral piſtils, or rather the piſtils terminate in ſeveral branches, which have their riſe from as many young fruits, or as many capſulæ containing ſeeds.

Whatever form the piſtils are in, they have certain apertures at their tops, or clefts, continued their whole length, to the baſe or embrio of the fruit.

The ſeed veſſels conſiſts ſometimes of two, and for the moſt part of three pieces; for which reaſon they are called ſuits, as at a b c d, fig. 527.

Pl. 66.

524



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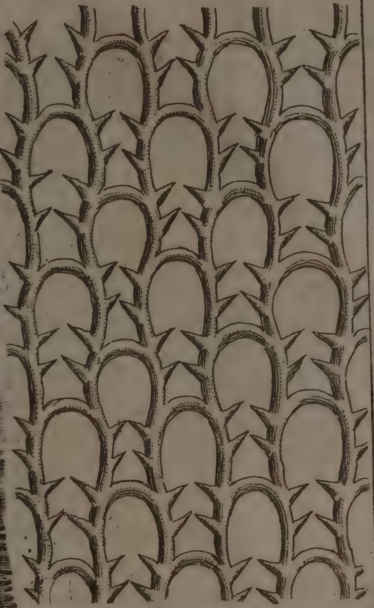

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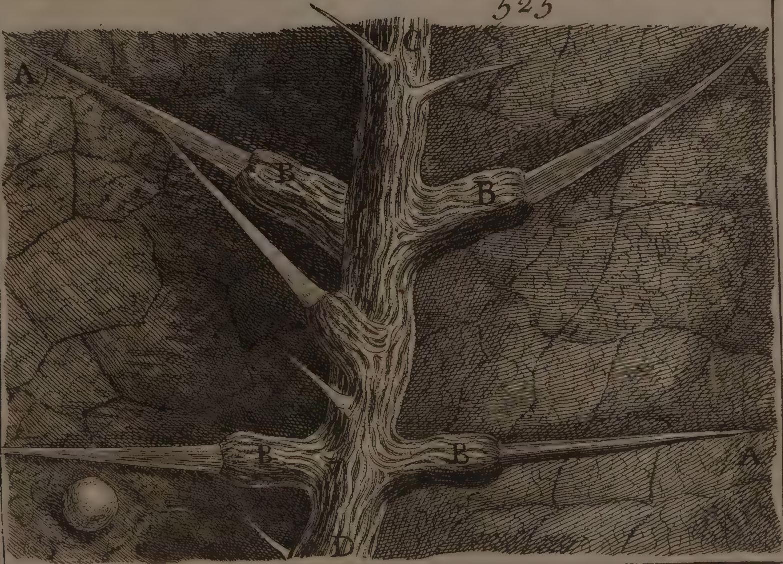

Front.^{9} Pag. 292.

Bowles ſc.

The outer part of each ſuit, according to Grew, is its floret, whoſe body or tube is divided at the top (like that of a cowſlip) into five leaves as at b, which forms a flower in miniature, and is all the flower in many plants, as mugwort, tanſye, &c. Upon the expanſion of the floret, the next part c, of the ſuit, begins to appear from within its tube, which may be called the ſheath (with reſpect to that within it). This ſheath in a ſhort time divides at top, through which aperture the blade d diſplays itſelf. This is the third part of the ſuit, and terminates in a forked point, about which appear little globules.

In ſome flowers every one of the before-mentioned florets is encompaſſed with an hedge of hairs, and every hair branched on both ſides, almoſt like a ſprig of fir, as at c d in golden rod, fig. 530. which ſhews one of the ſuits thereof as it appeared in the microſcope, in which at e is the little column or blade that contains the farina, which is alſo ſeen by itſelf at F.

The baſe of the floret is generally cylindrical, but ſometimes ſquare, as in French marigold, at a, fig. 531. and the leaves thereof, which for the moſt part are ſmooth, in the ſame flower are all over hairy. The middlemoſt of the three parts or ſheath b, is uſually faſtned to the top, or elſe at the bottom of the floret, and is rather indented than parted into leaves: the ſurface ſeldom plain or even, but wrought into five ridges and as many gutters, running almoſt parallel from top to bottom.

The inmoſt part or blade runs through the hollow of the two former as at a, fig. 531. and is faſtned with the floret to the convex of the ſeed caſe; the head and ſides of this part is always beſet round about with globulets. In ſome growing cloſe to the blade, as in common marigold; and in the French marigold, as at fig. 532. and others, upon little ſlender ſtalks. Theſe, as the blade ſprings up from within the ſheath, are rubbed off and ſtands like a powder upon them both. In ſome, as in chicory, they ſeem to grow within-ſide the ſheath, as will appear if it be ſplit [e] with a ſmall pin, as alſo in knap-weed they are very numerous.

The head of the blade is always divided into two, and ſometimes into three parts, as in chicory, fig. 533. which gradually curl outwards after the manner of ſcorpion graſs.

This deſcription agrees principally to the corimbiferous kind, as tanſy, camomile, &c. but in ſcorzonera, chicory, fig. 533. hawk-weed, mouſe-ear, and all the intibous kind, with many more. The piſtil is ſeparated from the foliature, ſo as to ſtand alone therein, every leaf a b c of the flower having a piſtil of its own; for which reaſon the baſe of each leaf is formed into a little tube a, fig. 533. that incloſes the piſtil, which commonly conſiſts of a ſheath and blade e; the leaf itſelf anſwering to the floret in other flowers. The blade (or rather ſtamina) is ſeen drawn out of its ſheath at f g of the ſame figure, and at g the head of the blade is opened into three parts, which are full of thoſe globular particles before-mentioned.

The time in which the flower is generated, is hardly any where, if at all taken notice of among ſo many obſervers of plants. It is therefore to be remarked, that all the parts of the flower in all flowers, are perfectly finiſhed long before they appear in ſight, uſually three or four months, and in ſome ſix. And that in perenial plants, thoſe flowers which appear in any one year are not formed in that, but were actually in being and intire in all their parts the year before. The flower of mezeron, which opens in January, is intirely formed about the middle of Auguſt in the foregoing year; at which time, if the green leaves of the bud be carefully removed, the leaves of the flower and ſeed-like attire, encompaſſing the ſeed-caſe, may be diſtinctly ſeen when placed before the microſcope.

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[e] Grew Ana. Plants, p. 170.

In order to obſerve the mealy powder or farina, let it be gathered in the midſt of a ſun-ſhiny day when all the dew is off, ſhake, or elſe gently bruſh it off with a ſoft hair-pencil upon a clean piece of white paper; then breathe upon a ſingle talc, and inſtantly apply it to the farina, which will adhere to it. If too great a quantity of powder ſticks to the talc, blow a little of it gently off, if not enough breathe on it again, and touch the farina with it as before, then fix it in a ſlider as before directed.

But I would here adviſe the curious not to neglect an examination of the little cells that contain the farina, and alſo of the piſtils and uteri, and other parts of generation of the flowers.

Fig. 534. repreſents the flower of St. Johnwort a little magnified, in which may be ſeen the ſtamina and their apices ſurrounding the ſeed-caſe, fig. 529. is one of the apices more magnified.

Fig. 530. repreſents one ſuit of golden rod flower, conſiſting of a ſeed-caſe A, and a ſtamina e, one of which is ſeen by itſelf at F.

Fig. 531. ſhews one of the ſuits of French marigold, or flos Africanus magnified, of which there are about twelve in one flower, each conſiſting of three pieces, the middlemoſt of which is ſeen alone at fig. 532.

Fig. 535. repreſents one ſuit of chryſanthemum-creet, conſiſting alſo of three pieces, of which there are about eighty in one flower.

Fig. 536. exhibits one ſuit of knapweed magnified, conſiſting of three pieces, a b is the ſeed-caſe, at the bottom of every ſuit.

Fig. 537. is a microſcopic repreſentation of one of the ſuits of marigold, of which there are about forty in one flower.

Fig. 533. repreſents the piſtil and blade, proper to each leaf in the flower of chicory.

Fig. 538. repreſents one of the flowers in the bud of mezeron perfectly formed in all its parts the year before it appears, but differs in ſhape as a fœtus doth when newly formed.

Fig. 539. ſhews the ſame flower cut open, wherein may be ſeen the ſpermatic thæcæ and the uterus.

Of the fruit of an apple, lemon, cucumber, and pear.

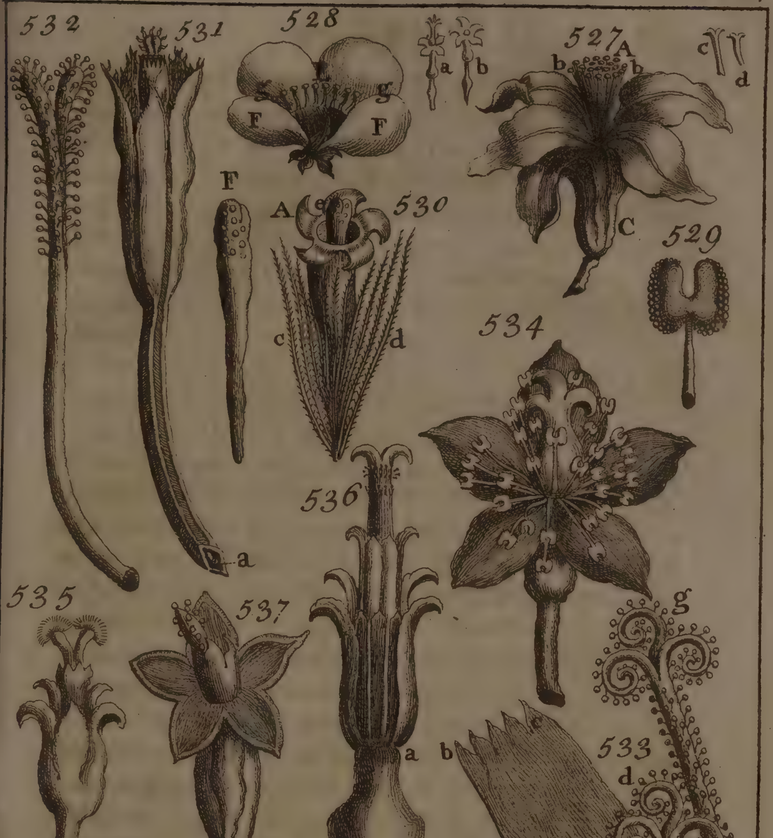
THE general compoſition of all fruit is one, that is, their eſſential parts are in all the ſame, and but a continuation of thoſe which have been already obſerved in the other parts of a plant. Yet from the different conſtitutions and tinctures of thoſe parts, the ſeveral varieties in fruits proceed.

An apple conſiſts of a ſkin, parenchyma, veſſels and core; the parenchyma or pulp is the ſame with that of the bark of the tree, as is apparent not only from the viſible continuation thereof, from the one through the ſtalk into the other, but alſo from their ſtructure, being both compoſed of bladders, with this difference, that whereas in the bark they are very ſmall and ſpherical (as may be plainly ſeen when viewed through the microſcope) here they are oblong and very large, in proportion to the ſize and tenderneſs of the fruit, being all uniformly ſtretched out by the arching of the veſſels, from the core towards the circumference of the apple.

The veſſels, as in the other parts of a plant, are ſucciforous, and for air, both the branches of the former and the ſingle veſſels of the latter are extremely ſmall, running every where together; not collateral, as veins and arteries do in animals, but the latter ſheathed in the former.

They

Pl. 67.



Front.^g Pag. 296.

Bowles ſc.

They are diſtributed into twenty principal branches, the ten outermoſt a little within the apple, are diverted from a ſtreight line into ſo many arches; from which a few ſmall branches are without any order diſperſed thro' the apple; the five middlemoſt and the five inmoſt run in a ſtrait line as far as the core, and are there diſtributed into as many leſſer arches, the former at the outer and the latter at the inner angles of the core, upon which laſt the ſeeds hang.

All theſe main branches meet together at the top of the apple, where originally they ran into the flower.

A lemon hath a three-fold parenchyma, ſeemingly derived from each other; the texture upon every derivation being ſomewhat altered, by being made more cloſe and elaborate. The outmoſt called the rind, hath the moſt open and coarſeſt texture, being compoſed of the largeſt threads, and theſe wove up into larger bladders. Thoſe little cells which contain the eſſential oil of the fruit, and ſtand near the ſurface of the rind, are ſome of the ſame bladders, but more dilated.

From this outmoſt parenchyma, nine or ten inſertions are produced, betwixt as many portions of the pulpy part towards the center, where they all unite into one body, anſwerable to the pith in the trunk or root of the tree; and are a conſpicuous demonſtration of the communication between the bark and pith.

Throughout this parenchyma the veſſels are diſperſed, but the chief branches ſtand on the inner edge of the pith, juſt at the extremities of every lamellæ from thoſe branches at the edge of the pith; other little and very ſhort ones ſhoot into the pulp of the fruit, upon which the ſeeds are appendant. In the center of the pith are eight or nine in a ring, which run through the fruit up to the flower.

Between the rind and pith, and thoſe ſeveral lamelated inſertions which join them together, ſtands the ſecond ſort of parenchyma, being cloſer and finer, and divided by the lamels into ſeveral diſtinct bodies, every one of them being an entire bag; in every one of which the parenchyma is contained; which is alſo a cluſter of other leſſer bags, all disjoined from one another, each having their diſtinct ſtalks of ſeveral lengths, by which they are all faſtned to the utmoſt ſide of the great bag wherein they are contained. Within theſe leſſer bags alſo the microſcope can ſhew many hundreds of bladders, conſiſting of extremely fine threads, as it were wove together into that figure; and within theſe bladders lies the acid juice of the lemon.

A cucumber hath alſo a three-fold parenchyma, the outermoſt is derived from the bark, which being expoſed for ſome time to dry, and then tranſverſly cut with a razor; not only the bladders but alſo the threads whereof the bladders conſiſt, are plainly viſible when viewed thro' the microſcope.

Throughout this parenchyma are diſperſed the ſap veſſels, in ten or twelve very large branches, each of which emboſoms another of air veſſels.

The middle parenchyma is derived from the pith, and divided into three triangular columns, within which are a diſtinct ſort of ſap veſſels, whence ſeveral ſmall and ſhort fibres ſhoot into the inmoſt parenchyma, whereupon the ſeeds do hang.

The inmoſt parenchyma wherein the ſeeds do lie (and which anſwers to the pulp of a lemon) ſeems to be produced from the ſeed-fibres, by three inſertions from the columns, and as many from the outmoſt parenchyma, and theſe reinſerted; it is divided into ſix triangular bodies, and every triangle into three ovals.

A pear, beſides the ſkin, conſiſts of a two-fold parenchyma of veſſels, tartareous knots, or grains, and a core; the ſkin when viewed in the microſcope, appears to be lined with a great number of theſe tartareous grains, which are alſo diſperſed round about the fruit, for about the thickneſs of the third of an inch, as will appear on applying a tranſverſe ſlice of a pear to the microſcope.

The outer parenchyma is of the ſame original and general ſtructure as in an apple, but the bladders not altogether ſo long with reſpect to their breadth.

The bladders here have alſo a different poſition from that they have in an apple, being in that all ſtretched out towards one common center, which is that of the apple itſelf. But here they every where bear a reſpect to the ſaid tartareous grains, every grain being the center of a certain number of bladders.

Throughout this parenchyma, the veſſels for ſap and air are likewiſe diſperſed into fifteen principal branches. The five utmoſt make as many arches, but commonly not ſo deep as in an apple; from theſe ſome ſmall fibres are diſperſed throughout the parenchyma. The ten inner branches proceeding to the ſeed, and from thence with the other five to the flower.

Next the core ſtands the inner parenchyma, conſiſting of ſmall roundiſh bladders, anſwerable to that of the pith, from which it ſeems to be derived.

Between this and the outer parenchyma, the ſaid tartareous grains begin (firſt) to ſtand nearer together, to grow bigger, and of a more unequal ſurface; and by degrees to unite into a body, in ſome pears, and eſpecially towards the core, they are almoſt as hard as a plumb-ſtone.

On cutting a pear lengthwiſe, through its center, theſe tartareous grains will be apparent.

At the bottom of the core in moſt pears, and a little below the center of the fruit, is a kind of umbelical knot; from whence extends a ſtreight channel, which opens at the middle of the core or ſtool of the flower, ſcarce wide enough to admit the ſmalleſt pin.

Of a plumb, and ſome other fruits of the ſame kind.

A Plumb conſiſts of a parenchyma, the two general kind of veſſels, and a ſtone; and in proportion to the bulk of the fruit, hath more veſſels than an apple or pear. Alſo in plumbs, all theſe veſſels are braced together into one uniform piece of net-work, every where terminating at an equal diſtance from the circumference, the ſkin is fibrous and tough.

The ſtone is compoſed of two, or rather three diſtinct parts, one of them the lining, taking its riſe from the parenchyma, which the ſeed branch brings along with it, through the channel in the ſide, and at laſt into the hollow of the ſtone, and is there ſpread all over it.

The foundation or ground of the outer and more bulky part of the ſtone, is the inner part of the parenchyma, upon which the tartareous parts of the ſap are continually precipitated, and thereby petrified, as appears on comparing the ſeveral ages of the ſame fruit together; on the ſurface of many ſtones, ſome of the ſaid tartareous parts appear in diſtinct grains.

An apricock is of the plumb kind, but ſome things are herein better obſerved, as firſt the poſition of the bladders of the parenchyma; for the tartareous parts of the ſap, not being here diſperſed in little grains, throughout the fruit as in a pear, but are all thrown off into the ſtone; therefore the bladders all radiate exactly to the center of the ſtone, conveying thereto the feculent ſap, in ſo many little ſtreams. This is beſt ſeen when the fruit is full ripe.

The gradual tranſmutation of the inner part of the parenchyma into a ſtone, is alſo more apparent in this fruit, and ſo are the three coats which ſerve for the generation of the ſeed; being now all very diſtinct and remarkable.

A peach hath a much bigger ſtone, and therefore when full ripe, it hath a more defecated or better refined juice; the reaſon why the ſtone is ſo great, is becauſe the veſſels run ſo numerouſly through the body of it; and ſo cauſe a more copious perſpiration of the lees therein.

A cherry is likewiſe nearly related to a plumb, but the bracement or reticulation of the veſſels, is here carried on farther, ſo as to be all round about contiguous to the ſkin.

A walnut is a nuciprune, or between a plumb and a nut, for the rind anſwers to the pulp, and the ſhell, as the ſtone, is alſo lined; but the ſeed-veſſels, which in a plumb run through a channel, made on purpoſe in the ſtone, do here enter as in a nut, at the center of the ſhell; by which means they are inveſted with a more fair parenchyma.

Of the grape.

A Grape is as it were a plumb with two ſtones, for their thickneſs are as hard as any other. The principal fibres run directly between the ſtones; and the ſmaller fibres, and make only one ſingle net; near the circumference they all meet together at the top of the grape. Many lignous fibres are alſo mixed with the ſkin itſelf, whereby it becomes very thick and tough.

The parenchyma, or pulp of a grape ſeems to be derived from the pith, at leaſt as far as the reticulation of the fibres.

The anatomical preparation of vegetables.

THOSE leaves of plants are only fit for this purpoſe, whoſe internal ſtructure is compoſed of woody fibres, and are of a pretty good thickneſs, as the leaves of oranges, lemons, jeſſamin, bays, roſes, cherries, apricocks, peaches, plumbs, apples, pears, poplars, pines, oaks, ivy, &c.

There are ſeveral other that have no woody fibres or veins, but theſe diſſolve without ſeparating, as thoſe of vines, and lime-trees.

The leaves are to be gathered [f] in June, or July, when they are full grown, and have not been damaged by worms, or caterpillars; put them into an earthen pot or large glaſs, with a good deal of rain-water, the pot or glaſs being kept uncovered with water, and as it evaporates a freſh quantity muſt be poured in. In about a month's time, ſome of the leaves will begin to putrify, but the others muſt be kept two months longer. When the two external membranes begin to ſeparate, and the green ſubſtance of the leaf to grow liquid, then it is time to perform the operation. The leaf is to be put into a white flat earthen plate or diſh, filled with clear water; then upon gently ſqueezing it with the finger, it will open on one ſide, and the green ſubſtance will run out; immediately on that the two outer membranes muſt be ſtripped off, chiefly in the middle, and along the nerves, where they adhere cloſely. If there be once an opening, they will go off very eaſily; the ſkeleton that remains between, is afterwards waſhed in clean water, and kept between the leaves of a book.

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[f] Phil. Tranſ. No. 416.

The method of preparing fruits, as apples, plumbs, cherries, peaches, and the like, is as follows:

The fineſt and largeſt pears, that are ſoft and not ſtony, are fitteſt for this purpoſe; firſt pare them nicely, without ſqueezing them, taking care not to hurt the ſtalk or crown; then put them into a pot of rain or freſh ſpring water, cover it, and let them boil gently, till they become throughly ſoft; then take them out, and put them into a baſon of cold water, then take out one of them, and holding it by the ſtalk with one hand, and with one finger and the thumb of the other hand rub the pulp gently off, beginning near the ſtalk, and rubbing equally towards the apex; and you will eaſily ſee in the water how the pulp ſeparates from the fibres, which being tendereſt near the extremities, there the greateſt care muſt be taken. No inſtrument is of uſe in this operation, except laſt of all a penknife, to ſeparate the pulp ſticking to the core. In order to ſee how the operation advances, fling away the muddy water from time to time, and pour on clean. All being ſeparated, the ſkeleton is to be preſerved in ſpirits of wine; the ſame is to be obſerved with apples, plumbs, peaches, and the like.

Carrots, and other roots, that have woody fibres, muſt be boiled without paring, till they grow ſoft, and the pulp comes off; not only ſeveral ſorts of roots, but likewiſe the barks of ſeveral trees, may be reduced into ſkeletons, preſenting rare and curious views of vegetables.

To preſerve the ſpecimens of plants.

PRepare two iron plates as large as the ſpecimens you intend to preſerve, let them be pretty thick, and very ſmooth on each ſide, with holes for ſcrews at each corner; then take your flowers, leaves, &c. when full ripe, and of their true colour, ſpread them on a brown paper, with the leaves as diſtinct as you can; if the flowers are large, more paper muſt be laid under them; and if thick you may pare away half thereof, as alſo of the ſtalk ſo as to lie flat; then put theſe between the iron plates, ſcrew them faſt, and ſet them in an oven for two hours; after which take out the flowers, and with a bruſh dipped in equal quantities of aqua fortis, and aqua vitæ, or brandy, paſs over the leaves and flowers; then lay them to dry on freſh brown paper, and take the quantity of a walnut of gum dragon, which in leſs than twenty-four hours will be diſſolved in a pint of water, and with a bruſh rub the back-ſides of the leaves and flowers to make them ſtick; then lay them into your paper-book, and they will always look freſh [g].

Of charcoal, or burnt vegetables.

Charcoal, or a vegetable burnt black, affords an object no leſs pleaſant than inſtructive; for if a ſmall piece of charcoal be ſuddenly broke, it will appear to have a very ſmooth ſurface, but if examined by the microſcope, abundance of pores are diſcoverable in many kinds of wood, ranged round the pith both in a circular and a radiant order; and moſt of theſe ſo exceeding ſmall, and ſo cloſe to each other, that but a very little ſpace is left between them to be filled with a ſolid body. Theſe pores, or rather tubes, are ſo extreamly ſmall, that in a line of them, one eighteenth part of an inch long, Mr. Hook reckoned no leſs than an hundred and fifty, therefore in a line an inch long were no leſs than 2700 pores, and in a circular area, or of a ſtick of an inch diameter, are contained 5,725,350 pores or minute tubes[h], a number that to ſome perhaps may ſeem incredible, were they not left to the judgment of their own eyes as to the truth thereof. In cocus, black and green ebony, lignum vitæ, &c. theſe perforations are abundantly ſmaller than thoſe of ſoft light wood; ſo prodigiouſly curious are the contrivances, pipes or ſluices, through which the juice of vegetables are conveyed.

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[g] Phil. Tranſ. No. 227.

To prepare or make charcoal of any kind of wood, in order to examine it with the microſcope.

THE body to be charred or coaled may be put into a crucible, a piece of a muſket barrel, a pot, or any other veſſel, that will endure to be made red-hot in the fire without breaking; cover it over with ſand, ſo that no part of it be expoſed to the open air. Then ſet it into a good fire, and keep it there till the ſand has continued hot, for a quarter, half, an hour, or two, more or leſs, according to the nature and bigneſs of the body. Then take it out of the fire, and let it lie till the ſand be very near cold. The wood may be taken out of the ſand well charred, and cleared of all its watery parts.

Of the texture of cork.

IF an exceeding thin ſlice of cork be cut off with a very ſharp penknife, or razor, and applied to the microſcope, in an ivory ſlider, or held between the nippers, it

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[h] Hook's Mic. p. 101.

it will appear to be all perforated and porous; having but a little ſolid ſubſtance in proportion to the empty cavity, as is manifeſt on a ſight of fig. 540. Theſe pores are not very deep, but conſiſt of many little cells, ſeparated out of one continued long pore, by certain diaphragms [i], viſible in fig. B, which repreſents them ſplit the long ways: hence the microſcope informs us, that the lightneſs of cork proceeds from its being a very ſmall quantity of a ſolid body, extended into exceeding large dimenſions, and alſo why it is a body ſo very unapt to ſuck in water, and conſequently to preſerve itſelf floating on the top thereof, though left on it never ſo long, and why it is able to confine air in a bottle tho' conſiderably condenſed, and preſſing very ſtrongly to procure a paſſage without admitting the leaſt bubble to paſs through its ſubſtance. As to the firſt, the microſcope hath informed us that the ſubſtance of cork is filled with air, and that this air is perfectly incloſed in little boxes or cells diſtinct from each other: this therefore makes it very plain, that neither water nor any other air can eaſily inſinuate itſelf into them, their being already within them an intus exiſtens [k]; for this reaſon pieces of cork are good floats for nets and ſtopples for vials, &c. and is capable of being compreſſed into a twentieth part of its uſual dimenſions, and to reſtore itſelf to its former ſtate by means of the included air in the before-obſerved conſtituent cells or bladders. Mr. Hook told ſeveral lines of theſe pores, and found that there were generally about ſixty placed endways in a line of the one eighteenth part of an inch long: whence there muſt be 1160 in the length of an inch, and in a ſquare inch 1166400; therefore a cubic inch muſt contain 1259712000, a thing almoſt incredible, did not the microſcope aſſure us of it by ocular demonſtration. If you cut off a piece from a board of cork tranſverſly to the flat of it, you will as it were ſplit the pores, which will appear juſt as they are repreſented at fig. B, but if a very thin piece be cut off parallel to the plane of it, the pores of it will be tranſverſly divided, and will appear as expreſſed in fig. A.

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[i] Hook's Mic. p. 113. [k] Ibid. p. 113.

Of a plant growing on the blighted, or yellow ſpecks of damaſk-roſe leaves, bramble leaves, &c.

IT is obſervable that in the months of June, July, Auguſt, and September, that many of the green leaves of roſes begin to dry and grow yellow, but eſpecially the leaves of the old ſhrubs of damaſk roſes, are all ſpotted with yellow ſtains, and the under-ſides juſt againſt them have little yellow hillocks of a gummy ſubſtance, and ſeveral of them have ſmall black ſpots in the midſt of thoſe yellow ones. Upon examining theſe with the microſcope, multitudes of little black bodies like ſeed-cods were perceived to ſpring out of ſeveral ſmall yellow knobs, and to be faſtned to theſe knobs by a ſmall ſtraw-coloured and tranſparent ſtem, many of thoſe hillocks were bare as if thoſe bodies lay yet concealed, at at G, fig. 541. In others they were juſt ſpringing out, as at A; in others, as at B, they were juſt out, with very little or no ſtalk; in others, as at C, the ſtalks plainly appear; in others, and at D, thoſe ſtems were grown bigger and larger; and in others, as E F, &c. thoſe ſtems and cods were grown a great deal bigger, and the ſtalks more bulky about the root, and very much tapered towards the top: as they increaſed in bulk they began to turn their tops towards their roots, in the ſame manner as that of moſs is obſerved to do. The whole ſquare of this figure repreſents a ſmall part of a roſe-leaf no bigger than the letter H.

Theſe kind of vegetable ſprouts are to be found on ſeveral kinds of roſe-leaves, and on the leaves of divers ſorts of briars, and on bramble leaves in ſuch cluſters, that three or four hundred of them make a conſpicuous black ſpot or ſcab on the backſide of the leaf.

Of mouldineſs, or the principals of vegetation ariſing from putrefaction.

MR. Leeuwenhoek obſerves, that mouldineſs on ſkin, fleſh, or other things, ſhoots up firſt with a ſtreight tranſparent ſtalk, in which a globular ſubſtance riſes that commonly ſettles at the top of the ſtalk, and is followed by another globule driving out the firſt either on the ſide or at the top, and that again is ſucceeded by a third, &c. all which form on the ſtalk one great knob, much thicker than the ſtalk itſelf; and this large knob burſting aſunder repreſents a kind of bloſſoms with leaves[1].

The blue, white, and ſeveral kinds of hairy mouldy ſpots that are obſervable on divers kinds of putrefied bodies, whether animal or vegetable ſubſtances, ſuch as the ſkin, raw or dreſſed fleſh, blood, humours, milk, cheeſe, &c. or rotten ſappy wood, herbs, leaves, barks, roots, &c. are a kind of ſmall but variouſly figured muſhrooms; a ſpecimen of which is repreſented at fig. 542. which is nothing elſe but the microſcopic appearance of a ſmall white ſpot of hairy mould found upon the covers of a book that was bound in ſheep's ſkin. Theſe ſpots appeared through the microſcope to be a very pretty ſhaped vegetative body, which ſhot out multitudes of long and ſlender cylindrical ſtalks, not exactly ſtreight, but bent with the weight of a round white knob growing upon the top of each as at A A A; others a little oblong as at B, others a little broken as at C, and others that were burſt aſunder forming a kind of bloſſoms with leaves, as at D.

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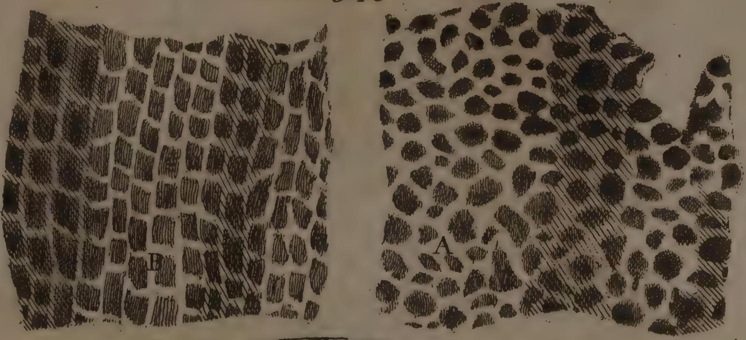
[1] Phil. Tranſ. No. 94.

Of moſs, &c.

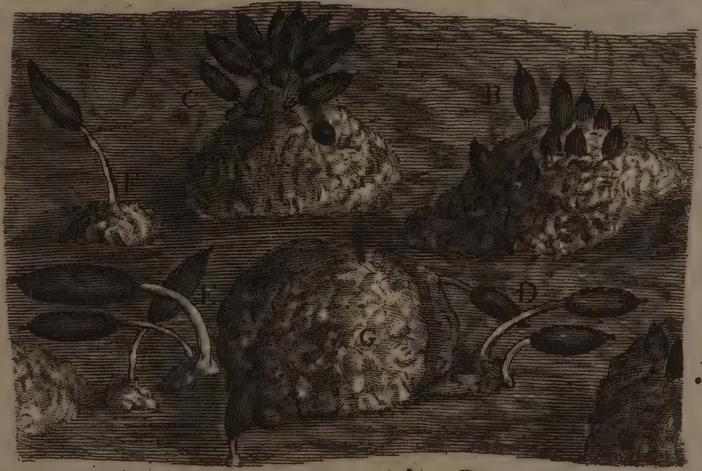
MOSS is a plant no leſs worthy a microſcopic conſideration than the moſt elegant plant that grows, and for its ſhape and beauty may be compared with any other. It has a root almoſt like a ſeedy parſnip, fig. 543. furniſhed with ſmall ſtrings and ſuckers, all of them being as curiouſly branched as the roots of much bigger vegetables; from this ſprings the ſtem or body of the plant, which is finely creaſed or fluted; on the ſides of this are cloſe and thickly ſet a multitude of well ſhaped leaves, ſome of them of a roundiſh, others of a longer ſhape; all the ſurface on each ſide the leaf is curiouſly covered with a multitude of little oblong tranſparent bodies, as at D, fig. 546. From the tops of the leaves proceeds a tranſparent hair or thorn; the ſtem ſhoots out into a long round ſtalk, which on cutting is found to be hollow without any knot or ſtop, from its bottom where the leaves encompaſs it, to the top on which grows a large ſeed-caſe A, covered with a thin and more whitiſh ſkin B, fig. 544. terminated in a long thorny top, which at firſt covers all the caſe, and by degrees, as that ſwells, the ſkin cleaves, and at laſt falls off together with its thorny top, leaving the ſeed-caſe to ripen, and ſcatter its ſeed, at a place underneath this cap B, which before the ſeed is ripe appears like a fluted metal button, without any hole in the middle; but, as it ripens, the button grows bigger, and a hole appears in the middle of it E, fig. 545. out of which, in all probability, the ſeed falls; for as it ripens by the proviſion of nature that end of this caſe turns downwards. On opening ſeveral of theſe dry red caſes F, they were found to be quite hollow; whereas when they were cut aſunder with a ſharp penknife when green, in the middle of this great caſe was found another ſmall round caſe, the interſtices between the two caſes being filled with multitudes of ſtringy fibres which ſeemed to ſuſpend the leſſer caſe in the middle of the other, in which without doubt the ſeeds were contained; it grows on the rotten parts of ſtone, bricks, wood, bones, leather, &c.

This ſmall vegetable is wanting in nothing of the perfections of the moſt conſpicuous vegetables of the world, and deſerves to be ranged in as high a ſtate; for we do not know but that all the contrivances and mechaniſm requiſite to a perfect vegetable, are crowded into exceedingly leſs room than this of moſs; for that plant already deſcribed, which grows on roſe-leaves, is ſo exceeding ſmall that near a thouſand of them would hardly make the bigneſs of one ſingle plant of moſs; and by comparing the bulk of the latter to that of the biggeſt vegetable (ſome trees being, as we are informed, near twenty foot in diameter in Guinea and Brazil) whereas the body or ſtem of moſs is generally not above one ſixtieth part of an inch, we ſhall find that the bulk of one will exceed that of the other, no leſs than 2985,984,000,000; and ſuppoſing the production of the roſe-leaf to be a plant, thoſe Indian plants will exceed it a thouſand times the former number, ſo prodigiouſly various are the works of the Creator, and ſo all-ſufficient is he in his performance of things which to man would ſeem impoſſible.

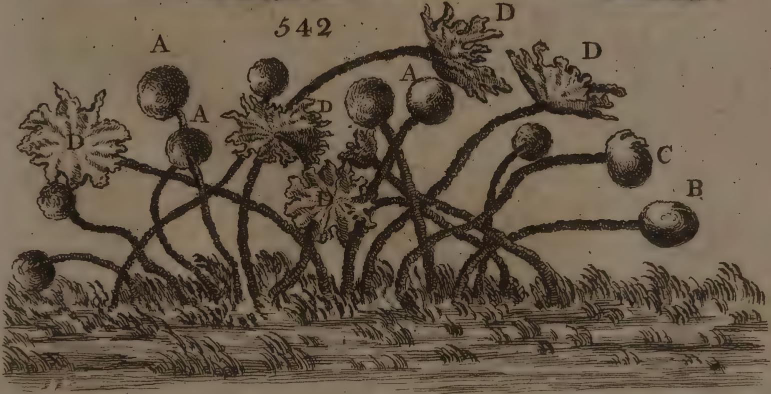
540



541



542



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Of ſponge.

THE microſcope hath ſhewn us, that ſponge is compoſed of an infinite number of ſmall and ſhort fibres, curiouſly joined together in the form of a net, as appears by fig. 547. which repreſents a piece of ſponge as it appeared before the microſcope, wherein may be ſeen the joints which for the moſt part are where only three fibres meet together, the length of each between the joints is very irregular, the diſtance between ſome two joints being ten or twelve times more than between others. The maſhes likewiſe of this reticulated body are alſo various, ſome bilateral, others trilateral, and quadrilateral figures, &c.

Of the beard of a wild oat.

THE beard of a wild oat is a body of a very curious ſtructure; it grows out of the ſide of the inner huſk that covers the grain of a wild oat. Its whole length when extended does not exceed an inch and a half. When the grain is ripe and very dry, which is uſually in the months of July and Auguſt, the beard is bent almoſt to a right angle, and its under part is wreathed and very brittle.

If you take one of theſe grains and wet the beard in water, the ſmall bended top will preſently turn and move round, and by degrees, if it be continued wet enough, the joint or knee will ſtreighten itſelf, and if it be ſuffered to dry again, it will gradually bend into its former poſture. Its appearance in the microſcope is repreſented by fig. 548. which ſhews part of the beard at the knee or bend. Its whole ſurface is adorned with little channels and interjacent ridges, which run the whole length of the beard, and are ſtreight where the beard is not twiſted, and wreathed where it is, being thickly ſet with ſmall briſtles; in the wreathed part was two very conſpicuous channels, which ſeemed to divide the wreathed cylinder into two parts, a bigger and a leſs, the biggeſt at the convex ſide of the knee; theſe clefts are filled with a kind of ſpongy ſubſtance, very conſpicuous near the knee.

This odly conſtituted vegetable is ſometimes uſed, as an hygrometer [m], to diſcover the various conſtitutions in the moiſture and dryneſs of the air; and this it does to admiration.

Of ſalts.

UNDER the denomination of ſalt, is to be underſtood moſt of that which gives ſolidity to bodies, is diſſolvable in water, and affects the taſte with a peculiar pungency. There are three diſtinct ſorts which generally paſs under this name, the fixed, volàtile, and the eſſential: the fixed is what remains after calcination, and is procured by diſſolving the ſaline parts of the aſhes in hot water, and evaporating it until the ſalt is left dry at the bottom; for that will not riſe in vapours. The volatile is what eaſily paſſes over the helm, as the ſalts of animals. The eſſential ſalt is that which is obtained by chriſtilization from the juices of plants, and is of a nature between the other two, and may moſt properly be termed eſſential, having no force uſed in its production.

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[m] If the reader is deſirous of one of theſe Hygrometers, he may be furniſhed with them at my ſhop, &c.

If there be in a ſtrict ſenſe any ſuch thing as a principal, ſalt is ſo; but then it muſt be termed foſſil ſalt, or ſal gemma; for this not only appears to be the plain production of nature, but to the moſt homogenous and uncompounded part nature can be divided into.

Its firſt appearance is in ſprings and rivers, being waſhed into them by ſubterraneous currents; thence by the ſun it is in ſome meaſure exhaled by vapours; from whence it again returns, in ſnow, hail, and dews (for common rain-water does not ſeem to partake of it;) from this return the ſurface of the globe is ſaturated with it; whence it re-aſcends in the juices of vegetables, and enters into all thoſe productions, as food and nouriſhment which the creation ſupplies.

To extract vegetable ſalts.

BURN any ſort of herb, flower, fruit, wood, or whatever it be, and make aſhes thereof; with the aſhes and pure water in its natural temper, make lee; which afterwards ſtrain through moiſt paper or a filter, ſo that it may become as clear as poſſible; then put the lee into a glaſs veſſel, and let it remain in balneo mariæ, until a great part of it evaporates; the quantity of water is not determined, generally five pounds of water will extract all the ſalt from two pounds of aſhes; ſalts extracted in this manner, are wont to melt when the air is ſoft; to prevent which, when you burn the materials, in order to reduce them to aſhes, it is requiſite to uſe with them a proper quantity of ſulphur; and if it happens that the aſhes are made to your hand, you may mix them with ſulphur, and keep the ſame at the fire, till ſuch time as it be burnt; by this means the ſalt will never come to run, but become more white and cryſtalline. There is no general rules for the quantity of ſulphur to be put into the materials you thus burn, but at a gueſs, to one hundred pounds of material, four or five ounces of ſulphur is uſually ſufficient. All ſalts have a peculiar and determined figure, which they always keep, although they are often reſolved into water, and afterwards congealed; yet notwithſtanding ſome ſorts of ſalts are obſerved to have two, three, and four ſorts of figures. Two ſorts have been ſeen in lettice, in the ſcorzoneras, in the muſk-melon, the ſcopa, in the roots of eſula, in the black hellebore, in endive, eye-bright, wormwood, ſorrel, and in ſhoots of vines; three ſorts in black pepper, and in incarnate roſes; four ſorts in white hellebore. Beſides the above-mentioned diverſity of figures which are found in ſalts, it is obſervable, that amongſt all ſalts, of what figure ſoever, there are found ſome cubical, which though they be never ſo often diſſolved and congealed, appear ſtill of a cubical figure, or inclining to it. To make the bodies of the ſalts when they congeal, remain diſtinct from each other, that their figure may be obſerved, and not be entangled and heaped together, it is neceſſary, that very great diligence be uſed in evaporating the lee; for if that be wholly evaporated, or too great a part thereof, the ſalts make a confuſed cruſt at the bottom of the veſſel; if the lees are left too weak, the ſalts require a very long time to congeal, and therefore it is requiſite to uſe ſuch diligence as is not to be gained without long practice.

Cryſtals of ſalts are ſuch a combination of ſaline particles, as reſemble the form of a cryſtal, variouſly modified, according to the nature and texture of ſalts.

The method herein uſed is this, diſſolve the ſaline body in water, after which filter the ſolution, which being evaporated until a little film appears upon it, runs into cryſtal. Diſſolution and filtration are made uſe of, that the ſalts may be purged from all droſs; otherwiſe if any foreign matter ſhould get in, not only the tranſparency of the cryſtals would be impaired, but their figure alſo would be mangled and broken.

Of the figures of ſalts.

IT is generally agreed, that all bodies have their ſalts, which produce many ſurpriſing changes, by their different configurations and impreſſions, both in ſolids and fluids, in things animate and inanimate. As to the figures of them, they are obvious to every beholder; their beauty and variety are ſo admirable, that ſcarce any thing in nature can entertain the eye more agreeably than theſe do, when it is aſſiſted with a good microſcope.

In common ſalt, we plainly diſcover quadrilateral pyramids with ſquare baſes. In ſugar, the ſame pyramids with oblong and rectangular baſes. In allum, they riſe with ſix ſides, ſupported with an hexagonal baſe. The cryſtals of vitriols, reſemble icicles, united one to another with great variety, among which lie ſome polygons. Sal-armoniac very elegantly imitates the branches of a tree; and hart's-horn looks like a quiver of arrows; Glauber's ſal mirabilis, which is made of common ſalt and vitriol, exhibits the figure of both ſalts. Nitre appears in certain priſmatic columns, not much unlike bundles of ſticks; among which there are interſperſed ſome of a rhomboidal, and pentagonal figure, which ſeem to come very near thoſe of common ſalt. Hence Lemery very juſtly remarked, that nitre could not be purified by any art or contrivance whatſoever, but ſomething of a ſal gem, or foſſil ſalt, would ſtick to it; but ſalt of tin out-does all for beauty, in which are lines like little needles, that ſpread themſelves every where from a point, as from a center, ſo as to repreſent a ſtar, much like what we ſee in the regulus of Mars.

Salts have this peculiar property, that let them be ever ſo divided and reduced into minute particles, yet when they are formed into cryſtals, they each of them re-aſſume their proper ſhape; ſo that they may be as eaſily diveſted and deprived of their ſaltneſs, as of their figure. Whence by knowing the figure of the cryſtals, we may underſtand what the texture of the particles ought to be, which can form theſe cryſtals. And by knowing the texture of the particles, we may determine the figures of the cryſtals. For ſince the figures of the moſt ſimple parts remain always the ſame, it is evident the figures which they run into, when compounded and united, muſt be uniform and conſtant.

Eſſential ſalts are made by expreſſing the juice of any plant, and ſetting it in a cellar to ſhoot; which ſome do in ſmall quantities.

Fixed ſalts are made as follows:

Take any plant, and burn it on a clean hearth, and rake the aſhes as long as any fire appears among them; put thoſe aſhes into an unglazed pan, which ſet in a calcining furnace, make fire about it till the pan is red-hot; where keep it, continually ſtirring the aſhes without any blackneſs. Then put them into a clean pan, and pour hot water upon them; when that water is ſufficiently impregnated with ſalt, filter it, and evaporate to a dryneſs, until the aſhes are left inſipid.

The ſalts of metals or minerals are to be come at by quenching them, when red hot, in water, then filtering, evaporating, and cryſtallizing.

If allum be burnt, diſſolved in water, and ſtrained, its cryſtals will conſiſt of two ſexangular planes, whoſe ſides are bounded by ſix other, three of which are quadrilateral, having between them three of a ſexangular figure; as at fig. 548.

Green vitriol affords cryſtals, which are made up of ten unequal ſided planes, the middle-moſt are pentagons, and each of its ſharp ends triangular planes; as at fig. 549.

The cryſtals of our inland ſalt-ſprings are of a cubical figure, as at fig. 550.

Salt-petre ſhoots into long cryſtals, whoſe ſides are ſix parallelograms; as at fig. 551.

It has been already mentioned, that vinegar owes its pungency to the ſalts which float therein; their ſhape is ſeen at fig. 552. Expoſe a drop or two of vinegar to the open air for an hour or two upon the object-carrying glaſs, that its watery parts may evaporate; then apply it to the microſcope.

The ſalts of ſugar candyed, are repreſented at fig. 553. The ſalts of nitre are ſeen at fig. 554. The ſalts of camphire, at fig. 555. Sal gem is repreſented at fig. 556. and ſal armoniack at fig. 557.

It is beſt to examine all ſalts in the ſmalleſt maſſes, for in them their ſhape will be beſt diſcovered.

On ſtriking fire with a flint and ſteel, &c.

ON ſtriking fire with a flint againſt a ſteel, little particles of ſteel are ſtruck of, and melted into globules by the colliſion; which will be evident on ſpreading a ſheet of white paper, and obſerving the place where ſeveral of theſe little ſparks ſeem to vaniſh. Mr.

Hook examined ſeveral of them with a microſcope, and found that a black particle, no bigger than a pin's point, appeared like a ball of poliſhed ſteel, as at fig. 558. and ſtrongly reflected the image of the window, and of a ſtick which he moved up and down between the light and it. Others were, as to their bulk, pretty round, but their ſurface not ſo ſmooth; ſome were cracked, as fig. 559. others broke in two, and hollow, as fig. 561. ſeveral others were found of other ſhapes; but that repreſented at fig. 560. was obſerved to be a big ſpark of fire, and ſtuck to the flint, by the root F, at the end of which ſtem was faſtened an hemiſphere, or hollow ball. It is alſo remarkable, that ſome of theſe ſparks are ſlivers, or chips of iron vitrified, others are only the ſlivers melted into balls, without vitrification [n], and the third kind are only ſmall ſlivers of the iron, made red-hot with the violence of the ſtroke given on the ſteel by the flint.

Many ſorts of ſand, ſome gathered on the ſea-ſhore, or on the ſides of rivers, and ſome found on the land, differ in the ſize, form, and colour of their grains, ſome being tranſparent, others opake, ſome have rough, and others quite ſmooth ſurfaces. It would be endleſs to deſcribe all the figures to be met with in theſe kind of minute bodies, they being ſpherical, oval, pyramidal, conical, priſmatical, &c. Mr. Hook trying ſeveral magnifying glaſſes, by viewing a parcel of white ſand, caſually hit upon one of the grains, which was exactly ſhaped and wreathed like a ſhell, which he ſeparated from the reſt of the granules, and found it to appear to the naked eye no bigger than a pin's point, but when viewed in the microſcope, it appeared as in fig. 562. reſembling the ſhell of a ſmall water ſnail [o]; it had twelve wreathings, growing all proportionably one leſs than the other, towards the middle or center of the ſhell, where there was a very ſmall round white ſpot. In this minute ſhell we have a very good inſtance of the curioſity of nature, in another kind of animals, removed by their ſmallneſs beyond the reach of the naked eye; and as there are ſeveral ſorts of inſects and vegetables, ſo ſmall as to have had no names; ſo likewiſe by this, we find there are alſo exceeding ſmall, or rather minute ſhell-fiſh. Nature, by the aſſiſtance of the microſcope, having ſhewn to us her curioſities, in every tribe of animals, vegetables, and minerals.

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[n] Hook's Mic. p. 44.

[o] Ibid. p. 80.

Of ſmall diamonds or ſparks in flint.

A Flint ſtone being broke in pieces, the inſide cavity of it appeared to be cruſted all over with a pretty candid ſubſtance, reflecting the light from ſome of its parts very vividly; but on examining it with the microſcope, the whole ſurface of that cavity could be perceived to be beſet with a multitude of little cryſtalline or adamantine bodies, curiouſly ſhaped, as at B, fig. 563. and afforded a very agreeable object.

An atom, or globule of quickſilver, when placed before the microſcope, ſeems like a convex mirrour, in which may be ſeen all the circumambient bodies; as the windows, trees, and furniture, &c.

Of mercurial powders, &c.

IN thoſe chymical preparations of mercury, which is called turbith mineral, mercurius vitæ, dulcis, ſublimate, precipitate, and mercury coſmetical, calomel, and all other mercurial powders, are found, when examined by the microſcope, to be full of minute globules of crude and unaltered mercury; which ſhews, that thoſe chymical preparations are not ſo purely exalted and prepared as they are preſumed to be, nor the mercury any way tranſmuted, but by an atomical diviſion rendered inſenſible.

The nature of ſnow.

MANY of the parts of ſnow are for the moſt part of a regular figure, and as it were ſo many rowels or ſtars with ſix points, and are as perfect and tranſparent ice [p] as any we ſee on a pool of water; at each of theſe ſix points are ſet other collateral points, and theſe always at the ſame angles with the principal points themſelves; that amongſt theſe, many others alike regular, but far ſmaller, may be diſcovered; there are alſo ſome others, which ſeem to have loſt their regularity, by various winds, being firſt gently thawed, and then frozen again into irregular maſſes; from all which, ſnow ſeems to be an infinite number of icicles, regularly figured, not only in ſome few parts thereof, but originally in the whole body of it; not ſo much as one particle of ſo many millions being originally indeterminate or irregular; that is, a cloud of vapours being gathered into drops, do forthwith deſcend; in which deſcent, meeting with a freezing wind, or at leaſt paſſing through a colder region of the air, each drop is immediately frozen into an icicle, ſhooting itſelf into points or icicles on all ſides from the center; but ſtill continuing their deſcent, and meeting with warmer air, ſome are thawed and blunted, others broken, but the greateſt number cling together in ſeveral parcels, and form

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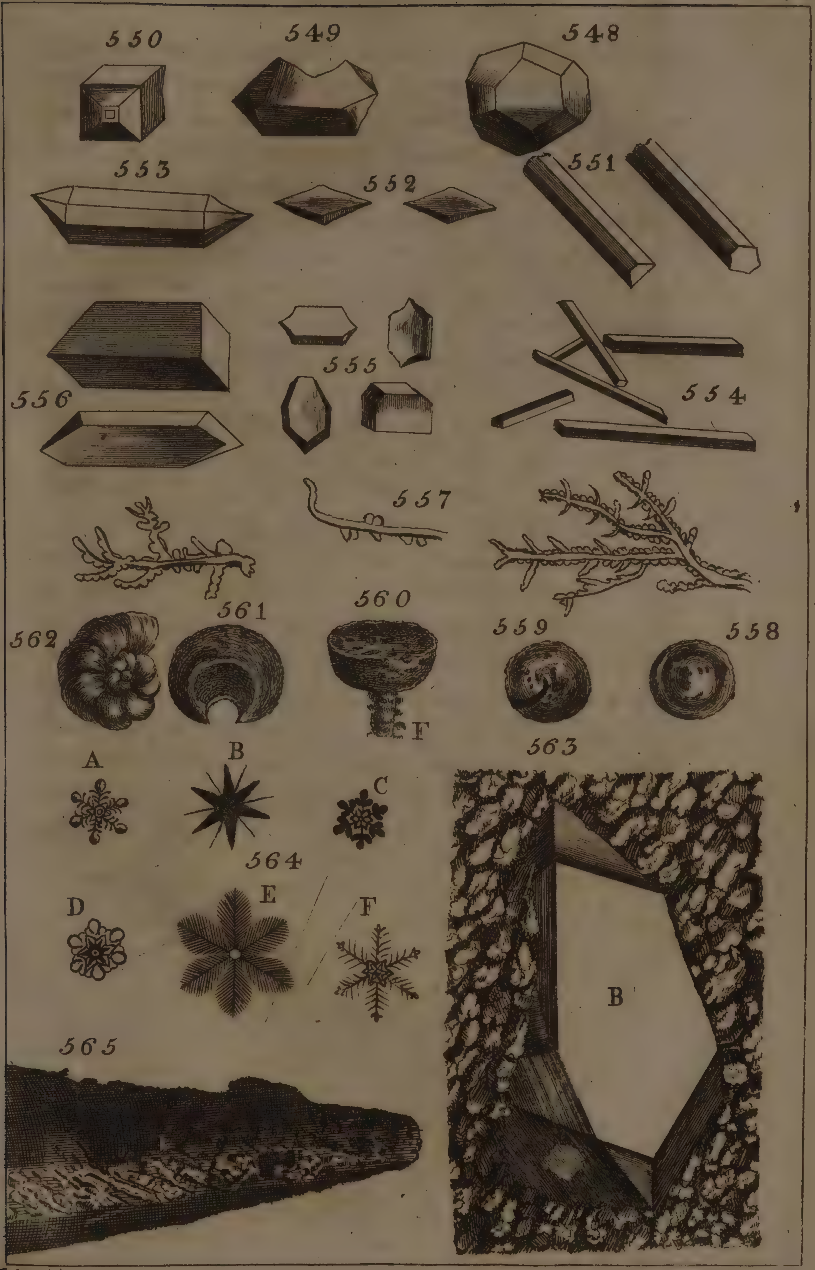
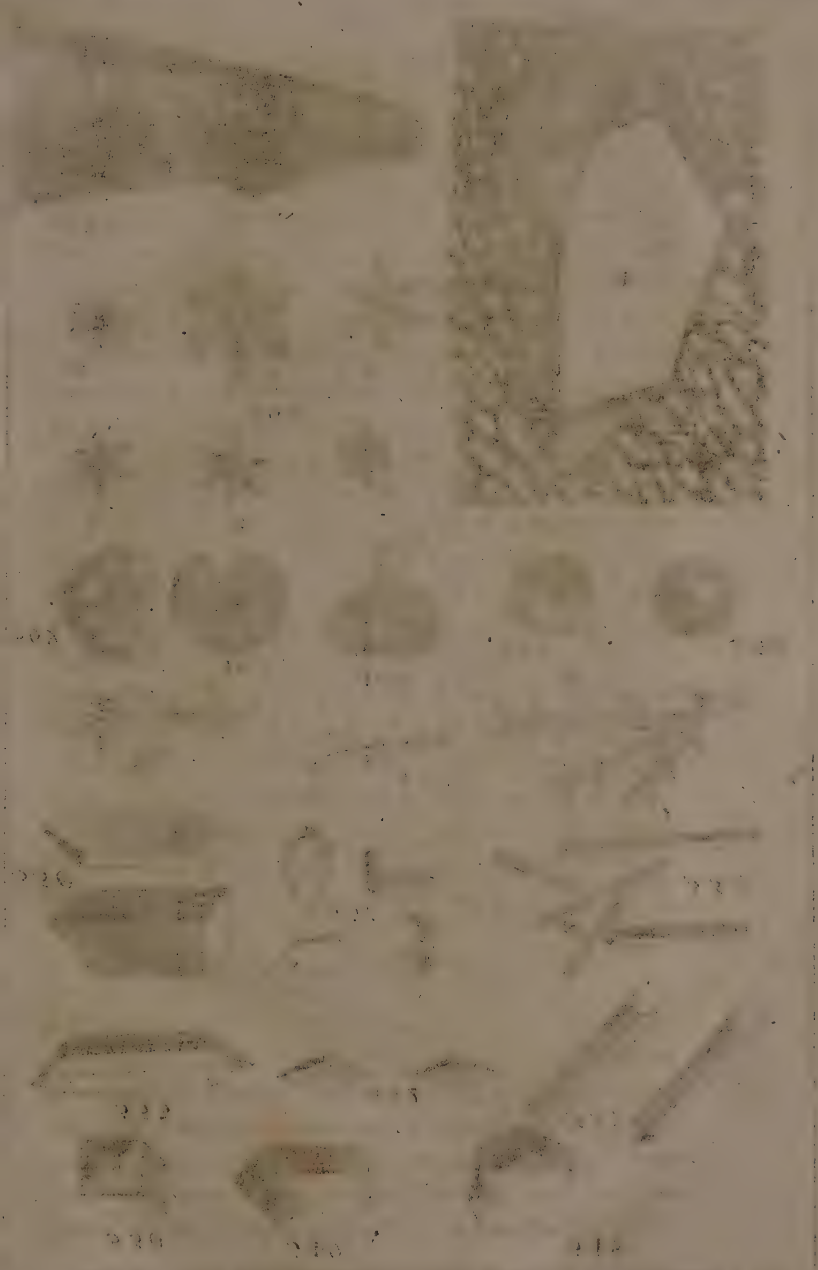
[p] Phil. Tranſ. No. 92.

Pl. 70.



J. Wigley. Sc.

Front.g Page. 320.



N° 10

form what we call flakes of ſnow; hence we underſtand why ſnow, though it ſeems to be ſoft, is really hard, becauſe it is a real ice, whoſe inſeparable property is to be hard, its ſoftneſs being only apparent. The firſt touch of the finger upon any of its ſharp edges or points inſtantly thaws them, otherwiſe they would pierce the fingers like ſo many lancets; and hence alſo why ſnow, though a real ice, and ſo denſe and hard a body is notwithſtanding very light, which is the extream thinneſs of each icicle in reſpect of its breadth: hence it alſo appears, why ſnow is white, becauſe it conſiſts of parts, each of which ſingly is tranſparent, but mixed together, appear white, as the parts of froth, glaſs, ice, and other tranſparent bodies, whether ſoft or hard.

A B C D E F, fig. 564. repreſents a few of an infinite variety of curious figures that are to be obſerved in ſnow; in which it was obſervable, that if they were of any regular figures, they were always branched out with ſix principal branches, of equal length and ſhape. As theſe ſtems were for the moſt part of the ſame make in one flake, ſo were they in differently figured flakes, very different; but this was conſtantly obſerved, that whatever figure one of the branches were of, the reſt were exactly the ſame.

Artificial things.

THE point of an exceeding ſmall needle appeared, when greatly magnified, like fig. 565. neither round nor flat, but very irregular, and though to the naked eye it was very ſmooth and ſharp, yet upon this examination, it appeared to be full of holes [q] and ſcratches; ſo unaccurate is human art in all its productions, even in theſe which ſeem to be the moſt neat, that if examined with an organ more accurate than that by which they were made, the more we ſee of their ſhape, the leſs appearance will there be of their beauty; whereas in the works of nature, the deepeſt diſcoveries ſhew us the greateſt excellencies; for in the ſting of a gnat, or a bee, the proboſcis of a butterfly, or flea, they appear, when examined by the microſcope, to be formed with the moſt ſurpriſing beauty, exquiſite workmanſhip, and an exact regularity of, and likeneſs in parts is preſerved in each particular of every ſpecies; an evident argument, that he who was, and is the author of all theſe things, is no other than Omnipotent; being able to include as great a variety of parts and contrivances in the moſt minute point, as in the largeſt body.

Fig. 566. repreſents a very ſmall dot, tittle, or point, that is generally the mark of a full ſtop or period. Amongſt multitudes that were obſerved by the microſcope, few could be found ſo round and even as this here delineated [r], but when greatly magnified, it appeared to be rough, jagged, and uneven all about its edges, and very far from being truly round, as at fig. 567. the moſt curious and ſmoothly engraved ſtrokes and points, when examined by the microſcope, look but like ſo many furrows and holes; and their printed impreſſions, but like ſmutty daubings on a mat, or uneven floor, made with a blunt extinguiſhed brand. Several pieces of ſmall writing, reckoned very curious of their kind, one of which in the breadth of a ſilver two-pence, comprized the Lord's prayer, the apoſtles creed, the ten commandments, and about ſix verſes beſides out of the bible, being examined by the microſcope, ſhewed what the writer had aſſerted was true, but withal diſcovered it to be compoſed of as ſhapeleſs, barbarous, and uncouth letters, as if written in Arabian and Chineſe characters.

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[q] Hook's Mic. p. 2.

[r] Hook's Mic. p. 2.

A part of the edge of a very keen razor was ſo placed between the microſcope, and the light, that there appeared a reflection from the very edges, and was perceived to be ſharper in ſome places than in others, indented at others, broader and thicker at others, and unequal and rugged; that part of the edge which is poliſhed by the hone, appeared to be prodigiouſly full of ſcratches, croſſing each other every way; beſides it had ſeveral deep furrows. That part of the razor which was poliſhed upon the wheel, looked almoſt as rough as a plowed field [a].

Mr. Leeuwenhoek cauſed himſelf to be ſhaved with the ſharpeſt razor he could pick out of five by the help of a magnifying glaſs. At firſt it was very ſoft and eaſy, but at laſt it grew ſo painful he could not endure it, and upon viewing it with his microſcope, he found in it many more notches than at firſt. In another he found little holes in ſix ſeveral places near the edge. He waſhed the back of his hand with plain water, and then with this ſame razor ſcraped off the little hairs, and on obſerving the

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[a] Hook's Mic. p. 4.

the razor again, found that thoſe little holes were turned into notches, and that ſeveral pieces of the razor were broken out. From whence it appears, that if the razor be too ſoft, it yields to the hairs, if too hard, the hair cauſes ſeveral notches in it. In ſhort when we obſerve through a microſcope the ſeveral notches there are in the fineſt razor, it is ſurpriſing how any of them can cut ſo well [t].

Fig. 568. repreſents a piece of exceeding fine lawn, as it appeared through the microſcope, which from the great diſtances between its threads, appears like a lattice, and the threads themſelves ſeem coarſer than rope-yarn.

Fig. 569. exhibits a microſcopic appearance of a very fine piece of ribband, its appearance is not much unlike that ſubſtance of which door-mats are made. If the ſilk be white, each thread appears like a bundle or wreath of tranſparent cylinders; if coloured, they appear curiouſly tinged, each of which affording in ſome part or other a vivid reflection, in ſo much, that the reflection of red appeared as if coming from ſo many garnets or rubies.

Hence it is evident, that there are but few artificial things worth obſerving with a microſcope, for which reaſon I ſhall conclude here; the productions of art being ſuch rude miſhapen things, that when viewed with a microſcope, we can obſerve very little in them but their deformity. The moſt curious carvings, appear no better than thoſe rude Ruſſian images mentioned by Purchas; where three notches at the end of a ſtick ſtood for a face: and the moſt ſmooth and poliſhed ſurfaces that we can poſſibly meet with, appear rough and uneven. Therefore why ſhould we endeavour to find beauties in things which were deſigned for no higher uſe than to be viewed by

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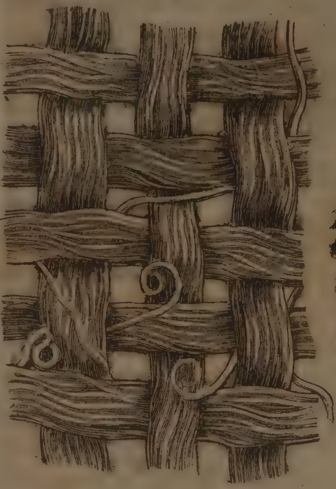
[t] Phil. Tranſ. No. 273.

568



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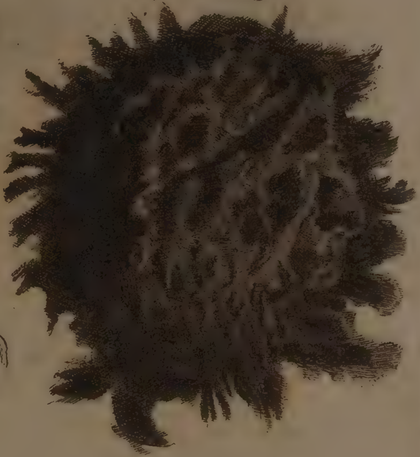

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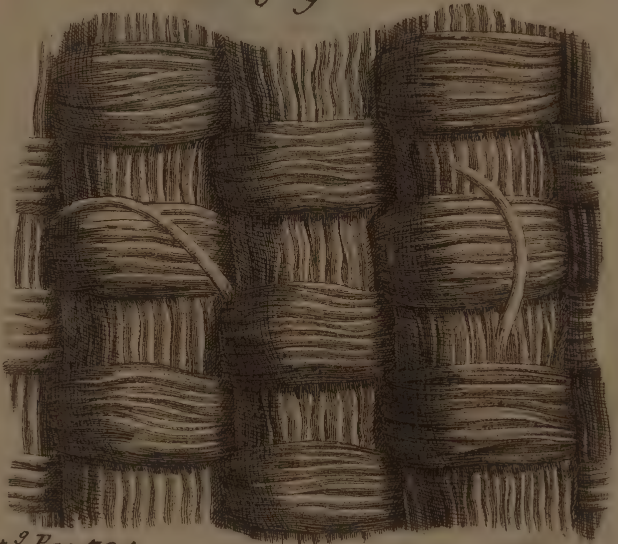

Front.^{9} Pag.324.

Bowles sc.

by our naked eye? but only that we may ſee the defects of human art, when compared to thoſe of nature, in whoſe forms there are ſomething ſo ſurprizingly ſmall and curious, and their deſigned buſineſs ſo far removed beyond the reach of our natural ſight, that the more we magnify thoſe minute objects, the more excellencies and myſteries appear; and the more we are enabled to diſcover the weakneſs of our own ſenſes, as well as the Omnipotency and infinite Perfections of the Great Creator.

FINIS.

A
CATALOGUE
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Made under the Inſpection and Direction of GEORGE ADAMS, Mathematical Inſtrument Maker to his Majeſty GEORGE the IIId.

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Where Gentlemen, Ladies, and Merchants, &c. may be ſupplied, with Inſtruments which are invented, and improved by him, as well as with thoſe contrived by the ableſt Mathematicians in Europe.

THE ſtudy of the mathematicks being now become a neceſſary part of every gentleman's education, we need not wonder at the great progreſs which this ſcience has, of late years, made in moſt parts of Europe; ſince it contains ſuch an inexhauſtible fund of uſeful knowledge, as is ſufficient to gratify every taſte, and employ every talent. The nobleſt genius may, in the purſuit of it, exert his utmoſt faculties; and the meaneſt will not fail of finding ſomething that is within his reach. The theory affords an ample field to the ſpeculative part of mankind, and the practice is productive of ſeveral advantages to men of action and buſineſs.

Mathematical inſtruments are the means by which thoſe noble ſciences, geometry, philoſophy, aſtronomy and opticks, are rendered uſeful in all the common and neceſſary occurrences of human life. By their aſſiſtance an abſtracted and unprofitable ſpeculation, is made beneficial in a thouſand inſtances: in a word, they not only enable us to connect theory with practice, but alſo inſtruct us how to turn bare contemplation, into the moſt ſubſtantial uſe, by making one of the moſt ſerviceable branches of learning, the natural way of rendering this knowledge general and diffuſive.

The knowledge of theſe leads to that of practical mathematicks, and experimental philoſophy; ſo that the uſes of mathematical and philoſophical inſtruments, make perhaps one of the moſt ſerviceable branches of learning in the whole world; and the natural way, therefore, of rendering this knowledge general and diffuſive, is by making that of its inſtruments ſo.

As practical mathematicks, and experimental philoſophy, teach us the powers of nature, the properties of natural bodies, and their mutual actions on one another; this knowledge cannot be attained without inſtruments, and the concluſions and proofs we expect from it, depend very much upon their exactneſs. In order therefore to give a ſufficient ſatisfaction to thoſe who honour me with their cuſtom, it is my particular and greateſt aim to produce ſuch inſtruments as may facilitate the progreſs of mathematical and philoſophical learning.

In all my performances I endeavour not to augment the inſtruments with ſuperfluous ornaments, that they may be of frequent uſe to thoſe of middling fortunes, and alſo that their neatneſs may render them not unworthy of a place in the cabinets of the curious.

That their exactneſs may be particularly attended to, I always inſpect and direct the ſeveral pieces myſelf, ſee them all combined in my own houſe, and finiſh the moſt curious parts thereof with my own hands. That the conſtruction may be as ſimple and ſubſtantial as the uſe of each inſtrument will admit, it is my conſtant ſtudy to contrive them in ſuch a manner that they may be managed with the greateſt eaſe. I alſo have reſpect to their being made applicable to ſeveral operations, eſpecially when the extent of their uſes does not prejudice their ſimplicity, to the end that inſtruments may not be multiplied without neceſſity.

In the following catalogue I have ranged the inſtruments in claſſes under the heads of their ſeveral branches, and have numbered each particular inſtrument, ſo that if a gentleman is deſirous of any one or more of them, and is at any diſtance from London, he need only ſend me the numbers adjoining to thoſe he intends to purchaſe, and he ſhall be ſerved with fidelity, and at the loweſt prices.

Inſtruments for Geometry, Drawing, &c.

VAriety of pocket caſes of drawing inſtruments, in ſilver, braſs, ivory, or wood, from 10s. 6d. to 5l. 5s. Theſe contain more or leſs of the following articles, which limit their price.

1 Plain compaſſes for meaſuring lines, *&c.*

2 Drawing compaſſes, with moveable points, viz. an ink point for ſweeping circles, or arches of any determinate thickneſs, and a black lead point.

3 Drawing pens, either with or without a protracting pin.

4 Sectors, for finding proportions between quantities of the ſame kind, as between lines and lines, ſurfaces and ſurfaces, *&c.* either of box, ivory, braſs, ſilver, *&c.*

5 Plain ſcales, or,
6 Square protractors, or,
7 Parallel Rules, are
either of box, ivory, braſs, ſilver, *&c.*

8 Semicircle protractors, of braſs.

In the beſt caſes, the compaſſes are always made with ſteel joints, and the knibs of all the pens are made to open with a joint, in order to clean them, in which are alſo ſometimes put,

9 Hair compaſſes, ſo contrived on the inſide of one of the legs, that an extent may be taken to an hair's breadth.

10 Circular (or bow) compaſſes, with which a circle as ſmall as a pin's head may be deſcribed.

In a magazine caſe of drawing inſtruments, is generally contain'd all the above inſtruments, together with the following particuculars,

11 Drawing compaſſes, with moveable legs longer than thoſe of No. 2.

12 Strong compaſſes, with calliper and cutting points.

13 Beam compaſſes, for drawing larger circles, and taking larger extents.

14 Proportionable compaſſes, for the ready diminiſhing plans or drawings, in any aſſigned proportion.

15 12 Inch Braſs Sectors, of a new conſtruction.

16 Triangular compaſſes, for tranſferring three

points at once, from a map or any drawing to another copy.

17 A pointrel and feeder, having at its upper end an oval plate for clearing the drawing pen of any dirt or grit that may happen between the knibs, and in the middle thereof is a protracting pin.

18 Elliptical compaſſes, for deſcribing ellipſis of various excentricities.

19 Bows, for drawing curved lines.

20 Port craiyons.

21 Large plain ſcales.
22 Plotting ſcales.
23 Protractors.
} Sometimes theſe are all made in one inſtrument.

24 Plain and parallel rules, of ſeveral ſizes.

25 Ivory pallates for Indian ink and colours.

26 Gunners callippers.

27 The regular ſolids, or platonick bodies cut in wood.

28 Cylinder biſected.

29 Cones with all their proper ſections.

30 Flat plates, for deſcribing the conic ſections upon paper, deſigned for thoſe who are ſtudying that branch of ſcience.

In theſe magazine caſes, gentlemen may have what number of inſtruments they think proper.

Rules of all ſorts, for meaſuring of timber, ſtone, painting, brick-work, *&c.* at the uſual prices.

Surveying Inſtruments, *&c.*

31 PLAIN tables, with an index and ſights, whereby the draught or plan is taken on the ſpot, without any future protraction, having a compaſs fitted to one of its ſides, and the whole fixed upon a ball ſocket, with a three legg'd ſtaff, upon which it may be turn'd round, or faſten'd with a ſcrew, as occaſion requires.

32 Beighton's plain tables, with an index, whereby the line of ſights is always over the center of the table, the ſtation lines drawn parallel to thoſe meaſured on the land; and the table ſet horizontal by a ſpirit level. In this table the papers being ſquare, are readily laid together and compoſe the whole ſurvey in one view.

Theodolites for meaſuring angles, diſtances, altitudes, &c. Thoſe inſtruments are made various ways, ſome being more ſimple and portable, others more accurate and expeditious.

33 The plain theodolite, which conſiſts of four plain ſights, two faſtened to the limb, and two on the ends of the index, with a compaſs on the index plate, divided into degrees, and the limb ſubdivided into minutes by a nonius diviſion, the whole fitted on a ball and ſocket, and that placed upon a three-legg'd ſtaff.

34 Theodolites, with all the above particulars, and the addition of a teleſcope.

35 Theodolites of the lateſt improvement, being the moſt accurate inſtrument yet invented for ſurveying land, which may be ſet truly horizontal,

zontal, by parallel plates and ſcrews. On the index, and over the compaſs-box is fixed a double ſextant, which moves exactly in a vertical circle, with a ſpirit level, and over that a teleſcope, ſo contrived, that when the bubble reſts in the middle of the ſpirit tube, the interſection of the hairs in the teleſcope will cut an exact level. The double ſextant is divided in ſuch a manner as to ſhew on one ſide thereof the degrees and minutes of any altitude or depreſſion within the extent of its diviſions. On the other ſide are diviſions for taking the height of timber ſtanding in feet; and on the limb, there are alſo diviſions for meaſuring its breadth. It muſt be alſo obſerved here, that both horizontal and vertical angles are obſerved at the ſame time, which is extremely uſeful in laying down plots, when the hypothenuſal are to be reduced to horizontal lines; when the teleſcope is directed to any object, the whole inſtrument is fixed in ſo firm a manner, that on directing the teleſcope to the next, the limb remains entirely ſtedfaſt, which in other inſtruments of this ſort, is very difficult to be effected.

36 Circumferentors, the principal ſurveying inſtrument uſed in the Weſt Indies. It is very ſimple, yet expeditious in the practice, and conſiſts only of a braſs circle, with a compaſs divided into 360 degrees, on the center of which is ſuſpended a magnetic needle, and an index, on whoſe extremities are two ſights; the whole is mounted on a ſtaff, and ſometimes for conveniency, on a ball and ſocket.

37 Gunters, or four pole chains.

38 Air levels which ſhew the line of level, by means of a bubble of air and ſpirits of wine

hermetically incloſed within a glaſs tube for the pocket.

39 Air levels, with teleſcope ſights, mounted on a three-legg'd ſtaff; they have a particular contrivance, by which they may be adjuſted (if put out of order) to a true level at any one ſtation.

40 Gunners levels, generally called perpendiculars.

41 Levelling ſtaves

42 Plotting ſcales.

43 Feather edged ſcales.

44 Pantographers, for reducing, or enlarging, or copying plans of ſurveys, pictures of any kind, and reducing ſhadows of the human ſide face, and this without any previous habit of drawing.

45 Pedometers to meaſure the way in walking.

46 Perambulators, way-wiſers, or meaſuring-wheels, ditto for coaches.

47 Major General Williamſon's new inſtrument for elevating pieces of ordnance.

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48	REflecting telleſcopes, 12 inches.	5	5	0
49	Ditto 18 inches.	8	8	0
50	Ditto 2 feet. —	12	12	0
51	Ditto on a rack ſtand.	21	0	0
52	Achromatic proſpects for the pocket.	1	16	0
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54	Ditto 3 feet. —	3	3	0
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And ſo in proportion for any other length. All other ſorts of refracting telleſcopes at the uſual prices.

56	Wilſon's pocket microſcope.	2	2	0
57	Ditto. — —	2	12	6
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59	Ellis's and Wilſon's microſcope in one caſe. — —	4	15	6
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61	The double conſtructed microſcope.	6	6	0
62	Ditto with a triangular foot in a flat mahogany caſe. —	8	8	0
63	Culpepper's double microſcope.	3	3	0
64	A ſolar microſcope. —	4	14	6
65	A ditto. — —	5	15	6
66	The new variable microſcope.			
67	A ſolar microſcope, to be applied to a new invented camera obſcura, that may be uſed either in the ſun-ſhine, or with a lamp contrived for that purpoſe in winter evenings.			
68	A pocket camera obſcura.	0	10	6
69	A ditto. — —	1	1	0
70	A ditto larger. —	1	5	0
71	A pyramidical camera obſcura in wainſcot. — —	3	3	0
72	Ditto in mahogany.	4	14	6
73	An inſtrument for taking perſpective views. — —	6	6	0
74	Concave and convex mirrors, from — — 7s. 6d. to	26	0	0
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77	Opera glaſſes. —	0	8	0
78	Ditto. — —	0	15	0

79	Ditto.	1	1	0
80	Ditto.	1	11	6
81	Reading glaſſes in variety of frames, from 2s. 6d. to	3	13	6
82	Spectacles for the noſe.	0	1	0
83	Ditto.	0	3	6
84	Temple ſpectacles.	0	3	0
85	Ditto.	0	5	0
86	Ditto.	0	8	0
87	Ditto ſilver	0	15	0
88	Silver double joint ſpectacles, which neither preſs the noſe nor temples.	1	1	0
89	Ditto in ſteel.	0	14	0
90	Ditto.	0	9	0
91	Treble joint ſpectacle for the ladies.			
92	Ditto in ſilver.			
93	Spectacles of brazil pebbles either in ſteel or ſilver, at the uſual prices.			
94	Concave glaſſes for myopes or ſhort ſighted perſons, in great variety.			
95	Magick Lanthorns.			

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96 AIR pumps excluſive of any apparatus.

97	Single barrelled.	2	2	0
98	Small double barrelled.	4	4	0
99	Ditto larger.	6	6	0
100	A large table air pump.	10	10	0
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The apparatus to either of theſe according to the deſire of the purchaſer.

102	Portable barometers.	2	2	0
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105	Ditto with ditto and hygrometers.	4	14	6
106	Ditto with ditto and ditto, with glaſs doors.	6	6	0
107	Other barometers with open ciſterns of ſeveral curious conſtructions, of a new contrivance, with diagonal barometers, either with ſingle, double or triple tubes. Wheel barometers, &c. all at reaſonable prices.			
108	Farenheidt's thermometers.	1	11	6
109	Ditto for the pocket.	1	1	0
110	Botanic thermometers.	0	18	0

Aſtronomical and Geographical Inſtruments.

111	NEW Globes accurately delineated, neatly engraved, and adapted to an apparatus eaſy in application, and extenſive in their uſe, 18 inches diameter in ſtained frames.	9	9	0
112	Ditto in mahogany frames.	11	11	0
113	Ditto in carved frames.	24	0	0
114	New globes, 12 inches diameter in ſtained frames.	5	5	0
115	Ditto in mahogany frames.	6	16	6
116	New globes, 6 inches diameter in ſtained frames.			
117	Ditto in mahogany frames.			
118	Globes 3 inches diameter in frames.	1	11	6
119	Ditto in black caſes for the pocket.	0	10	6
120	Globes mounted with wheel-work, at various prices.			
121	Armillary ſpheres, 12 inches diameter.	21	0	0

122	An armillary dialling ſphere, ſo contrived as to explain the reaſon and nature, as well as to ſolve the moſt uſeful problems in ſpherics, and illuſtrate the theory of dialling, and is itſelf an univerſal ſun-dial.	
123	A ſphere ſhewing the real and apparent motion of the heavens, and ſolving the problems depending thereon.	
124	A planetarium, by which the annual motion of the planets, their ſituations and poſitions with reſpect to the earth and ſun, as well as to each other, with their direct ſtationary and retrograde appearances are clearly illuſtrated.	18 18 0
125	A tellurian, which explains the diurnal and annual motions of the earth and moon; ſhews the inclination and retrograde motion of the moon's orbit, and thereby the cauſes of the eclipſes of the ſun and moon, the cauſes of day and night, the viciſſitudes of the ſeaſons, the phaſes of the moon, the difference between a periodical and ſynodical month, the riſing, ſouthing, meridian altitude, declination, amplitude, and ſetting of the ſun and moon, &c.	26 15 0
126	Orreries, which ſhew all the above phenomena, with the motion of the inferior planets only, or with the motions of all the ſuperior planets and their ſatellites, with many improvements, are made by me at various prices, according to the	

intention or deſire of the perſons who propoſe to be purchaſers, from 130 guineas, to 150 0 0

Smaller inſtruments of this kind, deſigned to ſhew only a few of the particular phenomena, are made at various prices.

127	Aſtronomical quadrants, 3 feet radius. —— ——	130	0	0
128	Ditto, 2 feet radius,	70	0	0
129	Ditto, 18 inches radius,	50	0	0
130	Ditto, 12 inches radius.	31	10	0

And all other aſtronomical inſtruments, as ſectors for obſerving angular diſtances and differences in right aſcention, equal altitude inſtruments, and tranſit inſtruments, &c. of various prices according to their ſize, &c.

Navigation Inſtruments.

131	HADLEY's quadrant.	2	0	0
132	Ditto, ——	2	12	6
133	Ditto. ——	3	3	0
134	Ditto. ——	4	4	0
135	Hadley's ſextant. —	8	8	0
136	Dr. Knight's ſteering compaſs.	2	12	6
137	——————— azimuth compaſs.	5	15	6

Theſe with all ſorts of ſcales, rules, and all the inſtruments uſed in experiments of natural philoſophy, for mechanicks, pneumatics, hydroſtatics, &c. are made, when ordered, at moderate prices.

To enumerate all the various articles that are uſed in making experiments, or for other purpoſes, would alone fill a volume. I have therefore ſelected the principal inſtruments in uſe, to moſt of which I have affixed prices and numbers, for the eaſe of thoſe gentlemen and ladies at any diſtance from London, who may have occaſion to write for any of the above inſtruments,

To their humble ſervant,

GEORGE ADAMS,

At No. 60. in Fleet-Street, LONDON.